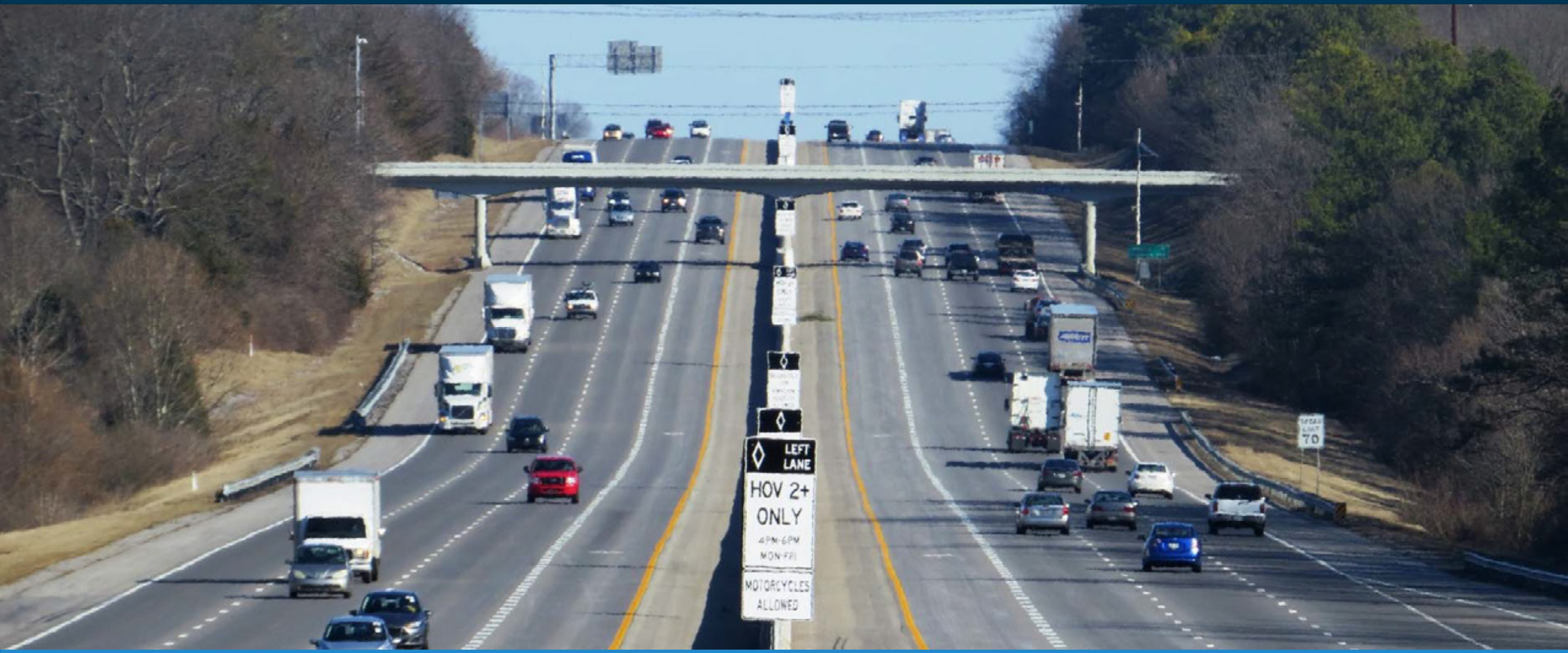
NASHVILLE AREA Metropolitan Planning Organization

PARSONS BRINCKERHOFF



NASHVILLE AREA MPO

Managed Lanes Preliminary Feasibility Assessment

February 2015

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Acronyms

ATM	Active Traffic Management
BOSS	Bus on Shoulder System
BRT	Bus Rapid Transit
EPA	(U.S.) Environmental Protection Agency
FHWA	Federal Highway Administration
HOT	High Occupancy Toll Lane
HOV	High Occupancy Vehicle
HOV2	High Occupancy Vehicle with at least 2 occupants
HOV3	High Occupancy Vehicle with at least 3 occupants
HSR	Hard Shoulder Running
ILEV	Inherently Low Emissions Vehicle
MTA	Metro Transit Authority
MPO	Metropolitan Planning Organization
MUTCD	Manual on Uniform Traffic Control Devices
P3	Public Private Partnership
RTA	Regional Transportation Authority
RTP	Regional Transportation Plan
SOV	Single Occupancy Vehicle
TDOT	Tennessee Department of Transportation
TOT	Truck Only Toll Lane

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Executive Summary

Purpose of the Assessment

The Nashville Area Metropolitan Planning Organization (MPO) is responsible for planning and programming funds for regional transportation facilities in a 7-county area that includes Davidson, Maury, Robertson, Rutherford, Sumner, Williamson and Wilson counties. The MPO facilitates strategic planning for the region's multi-modal transportation system. It is comprised of an Executive Board, Technical Coordinating Committee (TCC), and professional staff. The MPO Executive Board, composed of local mayors from within these counties, adopts and periodically updates a 25-year regional transportation plan (RTP) that includes a comprehensive set of strategies aimed at improving the livability, sustainability, prosperity, and diversity of the Middle Tennessee region through investments in all modes of transportation and in close coordination with land use planning. Projects and programs proposed in the RTP are developed from a process that:

- Establishes goals developed from public input and other adopted plans;
- Monitors and analyzes transportation system performance;
- Identifies where transportation goals are not being met; and
- Assesses potential strategies for addressing specific transportation issues and needs.

The purpose of this particular assessment is to profile potential managed lanes concepts for the Nashville area, along with the unique mobility benefits that they can provide, and to determine which of those concepts might be viable in the Nashville region. Managed lanes currently exist on multiple roadways in the region, which expressly support the first and third of three overarching policy initiatives developed as part of the 2035 RTP. These are:

1. Create a Bold, New Vision for Mass Transit
2. Support Active Transportation and the Development of Walkable Communities
3. Preserve and Enhance Strategic Roadway Corridors

As the MPO updates its RTP, additional managed lanes facilities may be deemed viable and included as part of the update. Data and conclusions drawn from this assessment can be used to inform recommendations for the MPO's 2040 RTP update, and should also provide guidance for future analyses to be performed as part of the MPO's ongoing planning responsibilities.

The full report introduces the concept of managed lanes, discusses the various types of managed lanes and their operation, describes current managed lanes in the Nashville area, and, finally, identifies facilities that could provide a good opportunity for a pilot program showcasing the potential for added managed lanes in the Nashville area.

Why Managed Lanes?

The concept of managed lanes extends back for at least 50 years. The Shirley Freeway in the Washington, D.C. area opened an exclusive bus lane in the late 1960s. In the 1970s, high occupancy vehicles (HOV) were also allowed to access the lane. The use of HOV lanes continued to expand throughout the 1970s and 1980s. FHWA data identifies more than 300 operational HOV facilities in the United States.[1]

Other types of lane management have been around even longer, although they may not be recognized or labeled as such. One of the more common examples currently being used in the Nashville region is the regulation of truck access, in which trucks are restricted to the rightmost lanes on designated sections of interstate highways.

Lane management in its various forms has proven to yield significant improvements in traffic flow, operations, and safety. As time has progressed, the concept and methods of lane management have evolved and broadened. For example, HOV lanes – one of the earlier tools – are managed by restricting access based on vehicle occupancy. Access to HOV lanes may also be granted based on other vehicle characteristics, such as low-emission vehicles.

As more cities implemented HOV lanes, their operating characteristics came under greater scrutiny, and certain issues became apparent. If there were too many qualifying vehicles in the traffic stream, an HOV lane became as congested as the general-purpose lanes. On the opposite end of the spectrum, if there were not enough eligible vehicles in the traffic stream to utilize all of the HOV lane's capacity, its ability to move traffic was not being fully utilized. On congested corridors, this could create a major problem not only for traffic operations but for public perception of the HOV lane's value.

In response to this, the concept of a high occupancy toll lane, or HOT lane, was developed. High occupancy toll lanes still allow qualifying high occupancy or low emission vehicles to travel with no toll, but also allow non-qualifying vehicles to use the managed lane by paying a toll. The number of vehicles accessing the lane by paying a toll is controlled by variable or congestion toll pricing. Under this system tolls vary either by a fixed time of day schedule (as used on SR 91 in California) or through dynamic toll pricing (I-85 in Georgia) that regulates the toll based on actual operating conditions either in the managed lane, the general-purpose lanes, or both. This concept is coming into wide use throughout the United States with 25 HOT lanes currently operating as of October 2014.

The concept of managed lanes, however, extends far beyond HOV lanes and HOT lanes.

There are various types of managed lanes that operate across the United States and worldwide. Key types of managed lanes and general characteristics are identified below.

High Occupancy Vehicle (HOV) lanes require a minimum of two people (or, on some facilities, a minimum of three) traveling in the same vehicle in order to utilize the lane. No toll is charged, and no transponder is required. Motorcycles are commonly allowed in the HOV lanes. It is also common for hybrids, alternative fueled vehicles and other inherently low emission vehicles (ILEVs) to be allowed to use the HOV lanes. However, under MAP-21, this provision sunsets on September 30, 2017, unless Congress either extends MAP-21 or supersedes it with a new highway funding bill that extends this provision. The U.S. EPA administers the certification, labeling, and other regulatory provisions of the ILEV program and maintains an updated list of certified ILEVs at http://www.epa.gov/otaq/hwy.htm.[2]

High Occupancy Toll (HOT) lanes allow single occupancy vehicles (SOV) to use the lane for a fee (toll). HOV2 drivers may or may not have to pay a toll depending on the requirements of the specific

[1] http://www.ops.fhwa.dot.gov/publications/fhwahop09030/summary.htm
[2] http://ops.fhwa.dot.gov/freewaymgmt/hovguidance/chapter3.htm

facility. Also, some HOT lanes require transponders for all vehicles using the facility regardless of whether they are required to pay a toll. HOT lane requirements vary significantly by facility. Many facilities require no condition for use other than occupancy; others require registration and a transponder. Use of the HOT lanes on I-95 in Miami requires registration of the specific members of the carpool and these persons must live and/or work within a reasonable proximity of each other.

Express Lanes is a term that varies in use across the country. One of the more common definitions is that express lanes are managed lanes where all vehicles pay a toll regardless of occupancy or emissions. Like HOT lanes, these lanes use variable tolling to control demand, and therefore the operating conditions, in the lane. For purposes of this assessment, an "express lane" refers to any lane in which all vehicles are required to pay a toll. This type of managed lane is most often used in situations where revenues need to be maximized. This is often the case where outside funding is used to finance the construction of the facility rather than waiting for more conventional funding to be available. This can often speed up the construction of the facility by decades.

Truck Only Toll (TOT) Lanes as imagined in the United States permit only trucks to utilize the lanes, for a fee. While TOT lanes have been studied in the United States, as of now there are no operating TOT lanes in the United States. Port areas and major trucking hubs may provide the right environment for implementing TOT lanes in the future.

Truck Restricted Lanes are essentially general-purpose freeway lanes, except that semi trailers and truck tractors are not allowed in the lanes in order to enhance service for automobiles and other smaller vehicles. Tennessee state law allows trucks to be restricted to the two rightmost lanes on interstates and state access controlled, multilane divided highways with three or more lanes in each direction of travel (T.C.A. § 55-8-195). Truck restricted lanes may also be found in urban and suburban areas where through truck traffic is not allowed. For instance, in Atlanta, large trucks that do not have a destination inside of the I-285 bypass (the perimeter) must take I-285 or another facility that keeps them on or outside of the perimeter.

Bus Only Lanes, as the name implies, are lanes that only allow bus service. Bus Rapid Transit (BRT) is a prime candidate to operate in such an environment. As previously discussed, bus lanes were opened on a number of freeway facilities in the United States, and, with only a few exceptions, have since been converted to HOV or HOT lanes. However, bus only lanes exist on arterial facilities in several cities in the United States including San Francisco, Cleveland, Las Vegas, New York City, Boston, Los Angeles, Pittsburgh, and Portland.[3] Bus only lanes can significantly improve transit service; however, there may be issues with unused capacity in the lane. On arterials, there may also be a need to allow general-purpose traffic to enter the lanes to perform turning maneuvers. This can be alleviated, as it was in the location shown in Figure 1,[4] by prohibiting certain movements by general traffic.

Figure 1 — Bus Only Turn Lane on a San Francisco Arterial

[3] http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_352.pdf
[4] http://sf.streetsblog.org/wp-contentuploads/2014102014-10-02-15.23.31.jpg

Reversible Lanes are lanes designed to operate in the peak direction of traffic flow. Reversible lanes usually operate in one direction in the morning and the opposite direction in the afternoon. Two local examples include Victory Memorial Bridge over the Cumberland River in downtown Nashville, and a section of Hermitage Avenue between Korean Veterans Boulevard and Fesslers Lane (Figure 2).[5] In both cases, overhead signals are used to indicate in which direction each lane is currently operating.

Reversible lanes may also be managed with physical separation, particularly on high-speed, high-volume roadways. To allow the lanes to be reversed, they are taken out of service, usually around midday, and sometime in the evening or early morning so that barriers and channelization can be changed to facilitate flow in the correct direction. Contraflow lanes, sometimes called *zipper lanes,* are a variation of reversible lanes in which the direction of flow in one or more lanes is reversed by physically moving the center median barrier. Specialized equipment is used to accomplish this.

Figure 2 — Reversible lanes serving downtown Nashville commuters.

Hard Shoulder Running refers to opening a freeway shoulder for general traffic use, generally only during peak hours. Hard shoulder running can provide an increase in capacity at a relatively low cost. However, several issues must be addressed. These include whether the shoulder pavement is sufficient for increased traffic use, the loss of the shoulder for breakdowns, and issues related to proper speeds. Further, hard shoulder running must be implemented in an area with extended full shoulders. It is not possible to merge hard shoulder use back in the general-purpose lanes in multiple locations to avoid "pinch points" that often exist on bridges or underpasses. Hard shoulder running is often implemented in concert with advanced traffic management (ATM) strategies such as dynamic lane assignment and variable speed limit/speed harmonization.

As shown in Figure 3,[6] variable speed limits/speed harmonization allows speeds to be set to maximize flow, and, if hard shoulder running is implemented, to maintain speeds at a safe limit for shoulder operation (usually lower speeds than in regular travel lanes). Portions of Europe have embraced automatic electronic enforcement of variable speed limits. This is not the case in the U.S., and some implementations are actually advisory in nature. However, the white on black

[5] Image from Google Earth
[6] Source: Washington DOT

Figure 3 — Variable Speed Limits/Speed Harmonization with Integrated Dynamic Lane Assignment, Seattle, Washington

signage shown above in Figure 3, and the very recent deployment on I-285 in Atlanta, use the black and white signage format that is enforceable in the same way and by the same means as fixed speed limits (versus black on yellow or vice versa for advisory signs).

Dynamic lane assignment allows the shoulder to be opened or closed to traffic; it also provides a mechanism for traffic management during periods when regular travel lanes must be shut down due to crashes, other incidents, or construction. Also as shown in Figure 3 (far left HOV lane), dynamic lane assignment can be used to designate certain lanes as special use lanes and to vary that use over the day as conditions change. While there is not a large body of experience in the U.S. for dynamic lane assignment, no major enforcement issues have been reported. This is not surprising since dynamic lane assignment has many parallels with enforcing traffic on shoulders, which is familiar to motorists and enforcement agencies.

Bus on Shoulder or Bus on Shoulder System (BOSS) is similar to hard shoulder running, except that only transit vehicles are allowed to use the shoulder. When BOSS is used, a maximum speed is generally defined for shoulder operation (typically about 35 mph), as well as a maximum differential between shoulder speed and speeds in the general-purpose lanes (usually 15 mph). Bus on shoulder provides transit with a significant benefit under congested freeway conditions. It may also be appropriate under conditions that would not be ideal for hard shoulder running, since it involves a professional driver.

Ramp Metering regulates the number of vehicles allowed to enter a facility based on preset timing or the level of congestion that is occurring. Numerous studies have shown that the density of traffic – reported as the number of vehicles in a one mile segment of roadway – has a major impact on both speed and throughput. While counterintuitive, ramp metering, which meters the number of vehicles entering the freeway, and thus delays a vehicle's entrance onto the freeway, can actually result in lower overall travel times.

The assessment team reviewed the following characteristics for the region's major travel corridors in order to develop recommendations for further consideration:

- Existing patterns of congestion
- Current and projected traffic volumes
- Significant travel patterns, including average trip lengths and major origins/destinations
- Planned transportation improvements
- Constructability (for lane additions)

Based on this evaluation, the team made a preliminary identification of corridors in the Middle Tennessee region where managed facilities appear to have the greatest feasibility.

Recommendations

As previously discussed, there are numerous potential opportunities for lane management in the Nashville region, and no options should be discarded at this point. The question becomes: what should be the first steps moving forward? In deciding that, the potential for significant positive gains must be balanced against costs and risks. For this reason, the steps recommended here build on existing managed facilities in the Nashville region as well as additional strategies that can be brought online without extraordinary cost.

Again, no options should be discarded at this point. Higher cost strategies, such as additional lanes on the Inner Loop to develop new HOV, HOT, or express lanes may well have a place in Nashville's future. However, for instance, it may be possible to implement Hard Shoulder Running in a much shorter timeframe and at a lower cost. Recommendations are listed below based on their potential timeframe for implementation.

Short-Term

- Work with TDOT to continue their program to improve HOV performance/enforcement on the region's existing and planned HOV lanes.

- Look at potential transit improvements, such as new park and ride lots and/or additional routes/shorter headways, to take advantage of improved facilities. Transit enjoys an excellent synergy with managed lanes, and this synergy should be maximized.

  For example, the MPO's *Northeast Corridor Mobility Study* (2011) recommended Bus Rapid Transit (BRT) routes be established along Ellington Parkway (SR 6/US 31E) and Vietnam Veterans Boulevard (SR 386). The current Regional Transportation Plan includes projects to widen these two roads by adding an HOV lane. BRT vehicles would be able to use these new HOV lanes to provide premium transit service to people traveling between Gallatin, Hendersonville, Goodlettsville, and downtown Nashville.

  The *Northwest Corridor Transit Study*, currently underway, will also examine opportunities to use managed facilities to provide premium transit services linking the Nashville and Clarksville regions.

- Open a dialogue with TDOT to discuss the use of Hard Shoulder Running on most of the Inner Loop, including a facility-specific operational study to confirm potential viability and desirability. As part of the constructability analysis performed in this assessment, it was noted that the I-65 bridge over the Cumberland River would require significant improvement in order to handle HSR. However, most commuters into downtown can reach their destinations without traversing the loop's entire length, so this is likely not a fatal flaw.

- Consider performing a study for application of ramp metering to the regional freeway system. Network implementation of a sophisticated ramp metering system may be able to provide significant congestion relief at a good benefit/cost ratio.

  Ramp metering was recommended in the MPO's *Southeast Corridor High-Performance Transit Alternatives Study* (2007) for the section of I-24 linking Nashville, LaVergne, Smyrna and Murfreesboro, along with the construction of queue jumps at interchanges.

Medium-term

- Implement Hard Shoulder Running, if found feasible and desirable, on the Inner Loop along with required Dynamic Lane Assignment and Variable Speed Limits/Speed Harmonization. The shoulder use could be bus only or mixed transit/single occupant vehicles depending on the results of the study.
- Consider direct access ramps for HOVs/buses at appropriate interchanges.
- Conduct a comprehensive design and operations study for managed lanes in the Nashville region and incorporate recommendations into the MPO's plans and programs. Recommendations contained in this assessment can provide a starting point.
- Consider HOT operation for HOV lanes.

Long-Term

As the short and medium term plans outlined above are implemented, insight into the integration of managed lane strategies in the Nashville region will be gained. As the effectiveness and acceptance of strategies is better understood, specific facility/strategy pairs for future study and implementation are likely to become evident. Further, population growth, changes in technology, and changes in commuting patterns, the effects of which are currently unknowable will become evident.

While increases in population will increase travel demand, facility capacity may be increased through connected and autonomous vehicles. Also, telecommuting is becoming a viable and growing commute option. As this continues, peak hour demand will be less, perhaps significantly less, than it would be without the telecommute option.

Predicting the future with precision is not possible, however, openness to considering various, reasonable possibilities is possible. By considering facility and network management options, the Nashville region will be in a good position to take advantage of opportunities as the future presents them.

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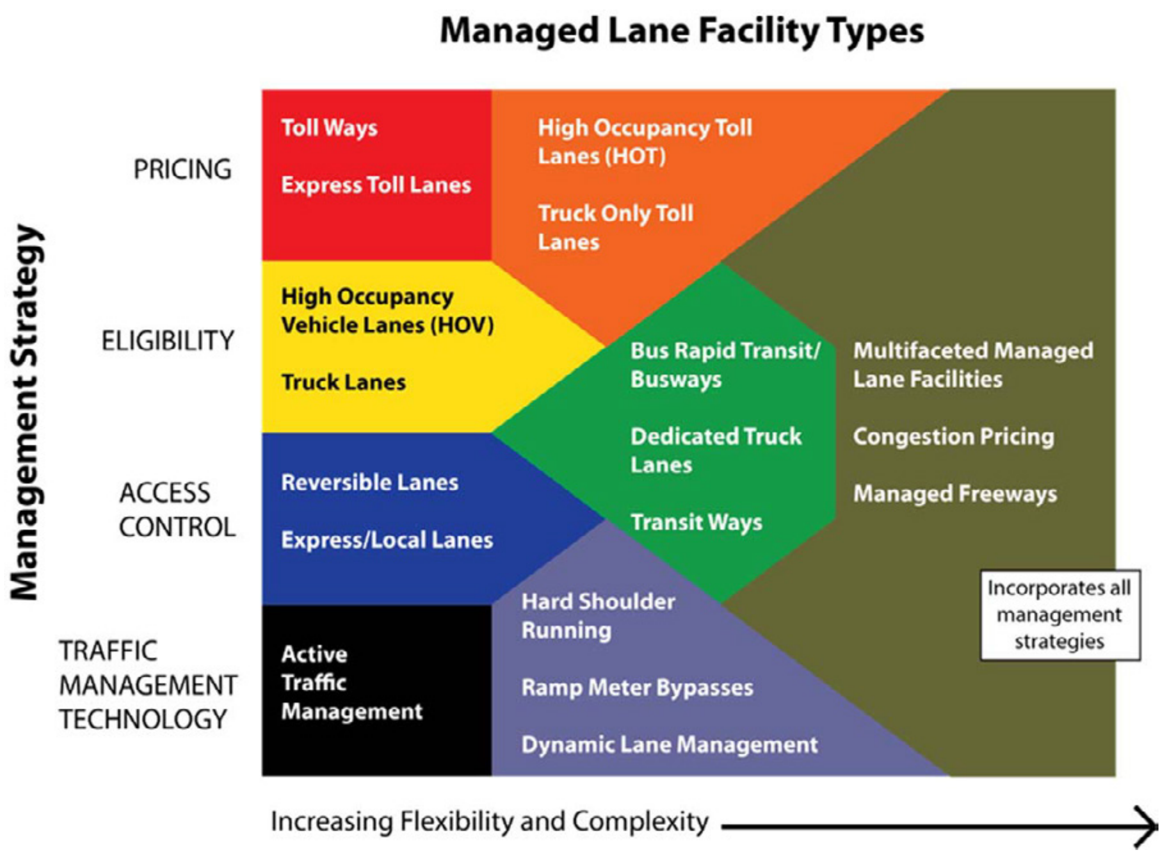
Introduction

Traffic congestion has been the bane of urban/suburban existence for decades. According to the Texas A&M Transportation Institute (TTI), traffic congestion cost the United States $121 billion in 2011.[7] In the Nashville metropolitan area, TTI reported almost 36 million hours of delay per year (33rd in the U.S.) and $801 million in total congestion costs. For many years, traffic congestion was thought to have only a single solution: Build More Roads. In light of increasing financial, social, and environmental costs, that approach is being rethought. Increasingly, forward thinking regions are looking for ways to make better use of their existing roadways, and for ways to make the most effective use of new capital improvements. Lane and facility management is moving to the forefront.

Lane management in its various forms has proven to yield significant improvements in traffic flow, operations, and safety. This assessment explores how it might be used in the Nashville region.

As time has progressed, the concept and methods of traffic demand management and traffic operations management have evolved and broadened (Figure 4).[8] While transportation facilities *exist* in three dimensions –length, width, and height – they *operate* in four dimensions, including time. Concepts such as ramp metering and variable time-of-day pricing help "engineer" the times when transportation facilities are used, effectively spreading peak overloads into more manageable

Figure 4 — Lane Management Universe



[7] Urban Mobility Report, December, 2012, Texas A&M Transportation Institute
[8] Source: Parsons Brinckerhoff, created from a TTI concept

demand.

Even when only considering three dimensions, the concept of telecommuting is an approach that helps manage demand by shifting where the person works rather than changing the physical dimensions of a transportation facility. By grasping this concept, Middle Tennessee has joined other forward thinking urban areas in addressing its transportation concerns using multiple innovative options rather than remaining stuck in the "Congest – Build – Congest – Build - Congest" cycle.

There are a large number of managed lane possibilities. Figure 4 illustrates the universe of management strategies available to the MPO.

The universe of lane management strategies that could be deployed in the Nashville region is broad, and ranges from relatively simple tools to more complex and cutting edge strategies. Nearly all of these strategies have been implemented successfully in other urban areas. Their applicability to Nashville depends on operational and geometric characteristics of the roadways, public acceptance, and – very importantly – the region's goals.

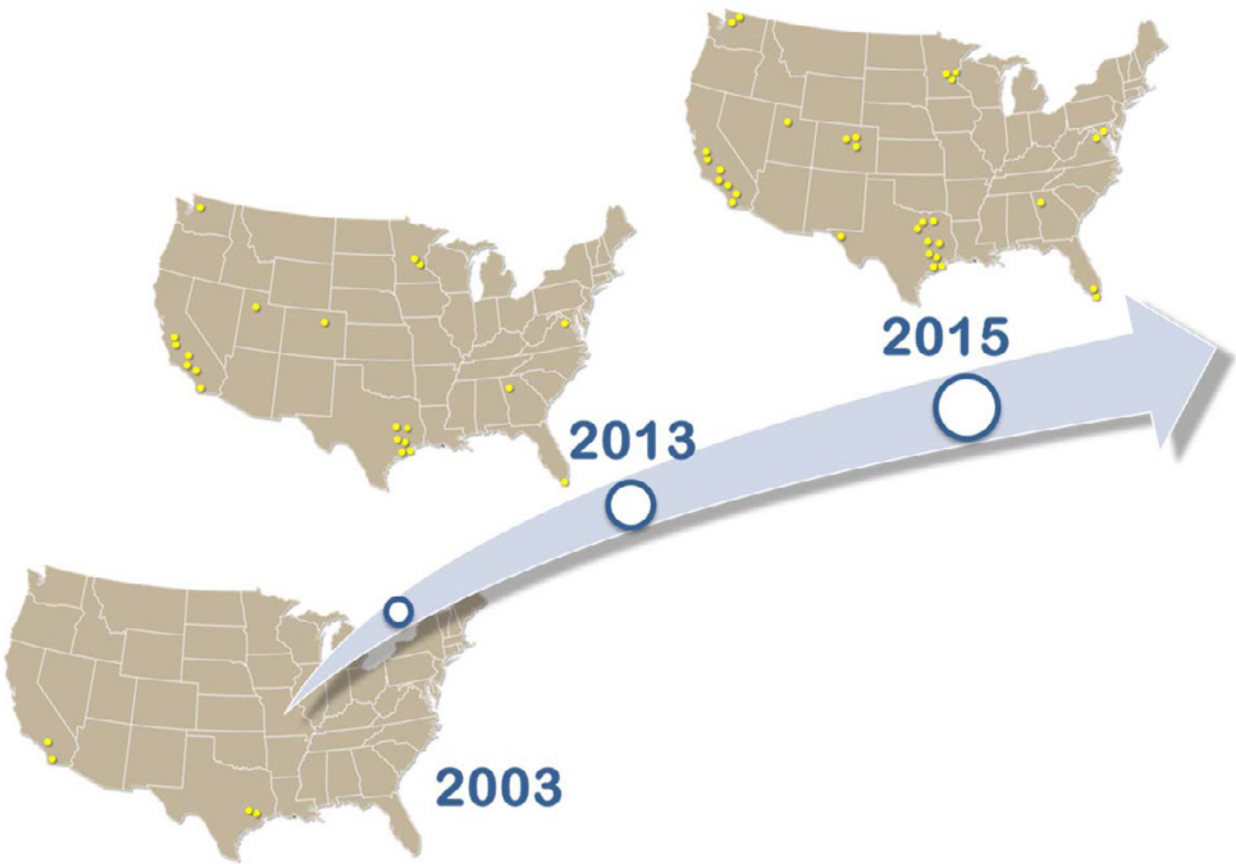
This assessment will discuss and provide examples of lane management strategies that are likely to provide the best results for Middle Tennessee. However, this assessment is intended to be broad in nature, and follow-up study of specific strategy and corridor combinations will be needed as these strategies move forward in the Nashville region. This assessment will provide a solid base for identifying the potential of successful combinations of strategies and corridors to benefit overall mobility in the Nashville region.

Managed Lanes in the United States

The Explosive Growth of Priced Managed Lanes

In the United States, the number of priced managed lanes has increased dramatically in the 21st century (Figure 5) [9]. In 2003, only three priced managed lane projects were implemented in the United States. Today, there are more than 25 and the number increases almost monthly. The concept is well proven and is shown to be a successful way to provide reliable capacity that can remain congestion free and moving efficiently.

Figure 5 — Managed Lanes Growth in the United States, 2003–2015



Managed Lane Design

For almost any managed lane strategy, with the exception of ramp metering, design of the lane itself is very similar to the design of the adjoining general-purpose lanes. Criteria for horizontal and vertical curvature and virtually all other design parameters are the same as they would be for a general-purpose facility of a similar type. There are, however, two exceptions. These two exceptions are *how the managed lanes are separated* from the general-purpose lanes, and *how the access from*

[9] Source: Parsons Brinckerhoff

the general-purpose to the managed lanes is handled. Again, these apply to virtually any type of special use lanes.

Separation

Initially the separation of HOV lanes from general-purpose lanes was handled in almost all cases through the use of striping. A double white stripe indicated that lane changing maneuvers were not allowed, whereas a white skip stripe indicated points where vehicles could maneuver in or out of the HOV lane (Figure 6).[10]

Figure 6 — Double White Line Separation on SR 167 in Seattle, Washington

The initial HOT lane in the United States, SR-91 in Orange County, California (Figure 7),[11] used a more robust separation than the existing HOV lanes. SR 91 used pylons located in a buffer zone between the general purpose and the HOT lane.

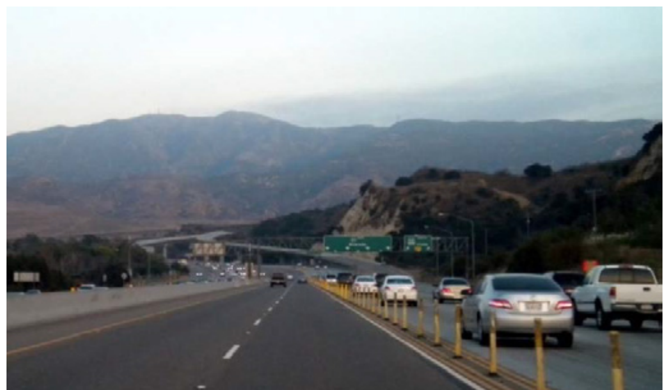


Figure 7 — Narrow Buffer with Pylons on SR 91 in Orange County, California

As HOT lanes continued to develop, buffers with flexible pylons were utilized in multiple facilities; however, the double white/skip white lines used in the HOV lanes were also employed. The decision about which type of separation to use hinges on the ability to manage toll collection from the single occupancy vehicle users. Whereas the original HOV lanes only required occupancy verification, the new HOT lanes require (1) occupancy verification, and (2) for single occupant vehicles, verification that tolls have been paid.

In the case of reversible lanes on limited access facilities (Figure 8), [12] a concrete buffer is used to provide positive separation between the general purpose lanes, and the managed lanes which for one direction depending on time of day, are moving in opposite directions. In other words, the concrete barrier between the reversible lanes and the general-purpose lane serves the same purpose as a concrete barrier between opposing lanes on a limited access facility that does not contain any managed lanes. On arterial type facilities, particularly in lower speed situations, the concrete barrier may not be needed.

Figure 8 — Reversible Managed Lane on the NW Expressway in Houston, Texas

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[10] Source: Parsons Brinckerhoff
[11] ibid
[12] Source: FHWA

Access

The second managed lanes design issue relates to the number of access points, and the type of access that will be provided. This decision needs to be made concurrently with decisions on the type of barrier between the managed lanes and the general purpose lanes, as access design is highly dependent on barrier type (Figures 9, 10 and 11).[13,14,15]

Figure 9 — Double White Skip Access Point to HOV Lane in Virginia

In designing entrance points for managed lanes on limited access facilities that operate on the inside lanes of the facility, care must be taken to ensure there will be sufficient weaving distance. Drivers wishing to use the managed lane must have enough distance to merge over to the managed lane, and conversely, drivers in the managed lane must have space to merge to an exit. Without a reasonable weaving distance (usually 800 feet to 1000 feet per lane), serious errant driver maneuvers may occur, raising safety concerns and adding to congestion on the facility. The need for weaving distance can often limit the number of access points that can be provided. On the other hand, lengthening each access point can sometimes allow closer spacing between access points, since drivers feel less rushed to make a weave maneuver. Taken to the extreme, access can be allowed for the entire length of the facility. Striping and signing are used to indicate that the driver is entering a managed lane. Enforcement on facilities of this type, particularly if it is a HOT lane rather than an express lane, can become problematic.

Figure 10 — Entrance to Access Restricted HOV Lane

Finally, access points are often decided based on the amount of right-of-way that is reasonably available. If concrete barriers are desired, as currently contemplated for I-4 in Orlando, Florida, there must be sufficient right-of-way to develop appropriate shoulders within the managed lanes envelope as well as the general-purpose lanes envelope. With striping separation buffers, and even buffer/pylon separation, shoulders can be shared to some extent between the general-purpose lane and the managed lane therefore requiring less right-of-way.

In situations where new lanes are being developed on existing facilities (as would be the case for the Nashville region), right-of-way is almost always a significant design consideration. Discussions with facility operators have not indicated any safety concerns that would lead to rejection of a particular type of barrier currently in use in the United States. In fact, a recent study done in California indicates that continuous access facilities may actually be safer than limited access facilities;

[13] Source: Virginia DOT
[14] Source: FHWA
[15] Source: Parsons Brinckerhoff

however, these findings should be confirmed with a larger data sample before relying on them for design decisions. There may be a tradeoff in compliance, due to the ease of entering a continuous access managed lane, but enforcement also plays a heavy role in determining violation rate. More sophisticated electronic enforcement algorithms could potentially offset the disadvantages of continuous access from a compliance standpoint.

Table 1 shows the evolution of managed lane design, in terms of the buffer types used.

Table 1 — Examples of the Evolution of Managed Lane Facility Design

Project	Year Opened	Facility Type	Total Lanes	Separation Type	Separation Width
SR 91, Orange County	1996	Concurrent	4	Channelizers	4 ft.
I-15, San Diego (original)	1998	Reversible	2	Barrier	22 ft.
I-394, Minnesota	2005	Reversible	2	Barrier	12 ft.
I-394, Minnesota	2005	Concurrent	2	Buffer	2 ft.
I-15, Salt Lake City	2006	Concurrent	2	Buffer	4 ft.
I-25, Denver	2006	Reversible	2	Barrier	22 ft.
SR 167, Seattle	2008	Concurrent	2	Line	2 ft.
I-15, San Diego (extension)	2009	Concurrent	4	Moveable	22 ft.
I-10, Houston	2009	Concurrent	4	Channelizers	14 ft.
I-95, Miami	2009	Concurrent	4	Channelizers	2 ft.
I-35W, Minnesota	2010	Concurrent	2	Line	None
I-680, Alameda County	2010	Concurrent	1	Buffer	4 ft.
I-85, Atlanta	2011	Concurrent	1	Buffer	2 ft.
SR 237 / I-880, San Jose	2012	Concurrent	2	Buffer	2 ft.
I-45 South, Houston	2012	Reversible	1	Barrier	3 ft.

Pricing Mechanisms for HOT Lanes and Express Lanes

Another issue that significantly impacts the effectiveness of price managed facilities is the pricing mechanism itself. *Static* pricing, in which the same price is applied for use regardless of time of day or day of week, is the simplest mechanism but it does not manage demand. *Fixed variable* and *dynamic* pricing are able to provide a demand management function. All three mechanisms are described below.

Figure 11 — Concrete Barrier Separated HOT Facility on I-15 in San Diego, California

Static Pricing

Static pricing refers to a mechanism whereby the toll is the same regardless of time of day or day of week. Dating back to the beginning of toll facilities in the United States, static pricing has been used. The use of variable pricing began in the 1990s with the primary intent of maintaining free flow traffic on managed facilities.

Static pricing was used as an initial phase for HOT lanes on I-15 in Salt Lake City as well as I-15 in San Diego. Both of these facilities started with a decal or "hangtag" program that allowed single occupant drivers to purchase access to the facility on a monthly basis for a flat fee, although FHWA has determined that such flat fees will not be allowed for future HOT conversions. Further, without some type of variable pricing, maintaining the high level of service that attracts drivers to the HOT lanes and express lanes is not possible. Therefore, for consideration of any type of priced managed lane, one of the two variable pricing strategies described below should be considered.

Fixed Variable Pricing

Fixed variable pricing refers to a toll pricing schedule that changes by time of day rather than conditions. Tolls typically vary by 30 minute increments. SR 91in Orange County, California and the Katy Freeway in Houston, Texas are two examples of fixed variable pricing. All facilities using fixed variable pricing routinely evaluate operating conditions on the facility to determine whether tolls for any particular time of day should be raised or lowered. For instance, for SR 91 tolls are evaluated every 90 days and there are set rules in place regarding whether and how much to change the toll.

Fixed variable pricing has the advantage of being very understandable to drivers. Also, the toll that a driver will pay is predictable, which has a high appeal to users.

Fixed variable pricing has one significant disadvantage. It is totally unable to react to conditions within the priced managed lane or the adjoining general-purpose lanes in real time. It is therefore not possible for fixed variable pricing to react to weather, crashes, or other incidents.

Dynamic Pricing

Dynamic pricing is able to vary based on conditions either in the managed lane, and/or the adjoining general-purpose lanes. It does this by using a computer algorithm that takes into account traffic conditions on the facility. Depending on the facility, the algorithm may take into account conditions on the priced managed lane, or conditions on both the priced managed lane and the general-purpose lanes. While tolls can vary, there are limits as to how often the toll may change, usually every five minutes. There are also often limits as to how much the toll can change. Again, this varies based on the business rules of the facility as well as the algorithm used.

Dynamic pricing has the advantage of being able to react to real-time traffic conditions. Therefore, dynamic pricing is best able to maintain traffic flow in the priced managed lanes under a variety of conditions that may be encountered. Unexpected changes in demand, or issues such as weather, or incidents in the managed lane or other lanes on the facility can be quickly responded to.

Dynamic pricing has the disadvantage of being much more complex. This means that communicating toll rates to drivers is more difficult, care must be taken to ensure that the toll rate displayed is the toll rate charged, and drivers do not have the assurance that the toll will be the same from day to day.

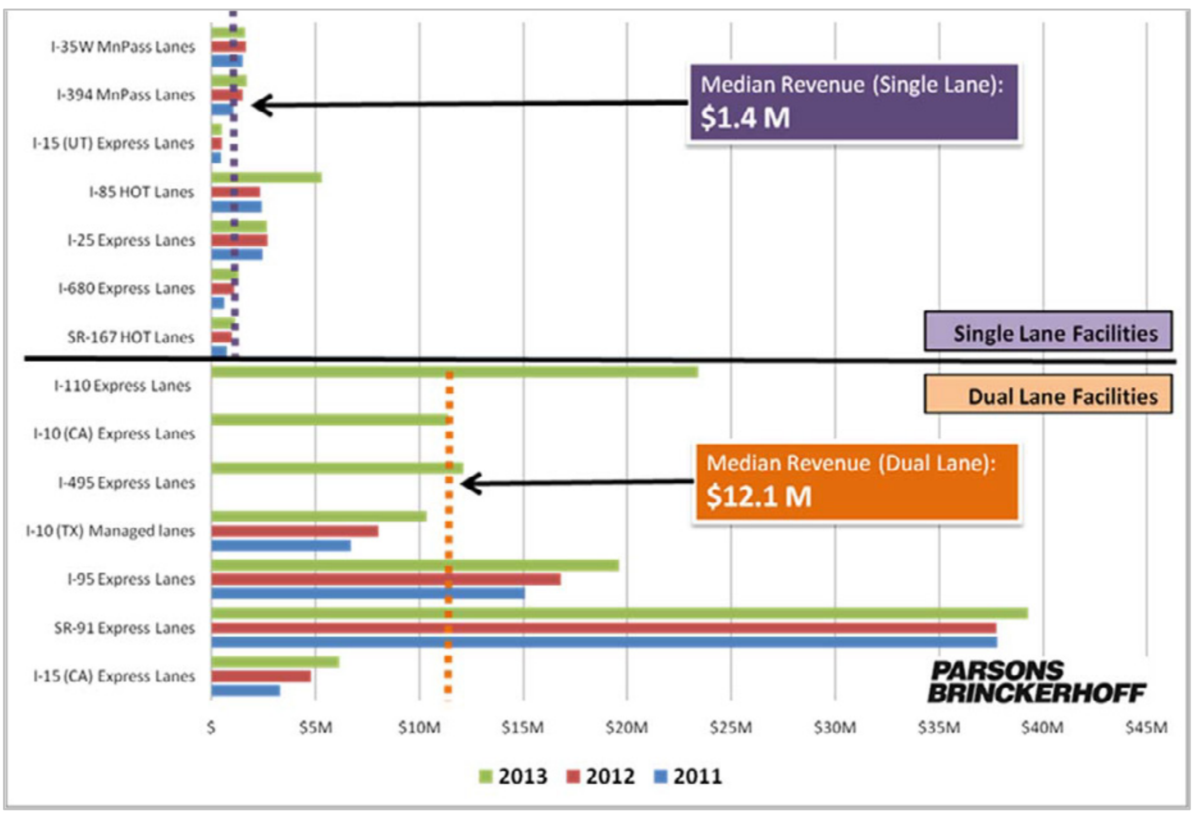
Interestingly, Parsons Brinckerhoff conducted interviews with multiple priced managed lanes facilities for another study. Respondents included facilities with fixed variable pricing and dynamic pricing. Respondents were asked whether they had ever considered converting from one to the other. While many have considered it, none had changed their method of toll setting, and no facilities seemed particularly inclined to make such a change in the near future. Both approaches seem to work well in managing traffic, and the mechanism selected has more to do with facility type and local preferences.

Revenues

As shown below in Figure 12, [16] annual revenue varies tremendously across active facilities in the United States. It should be noted, however, that few facilities, with some notable exceptions such as SR 91 in Orange County, California, generate significant revenue beyond their operating costs. Factors impacting revenue include the level of congestion on adjoining general-purpose lanes, the length of the facility, and the number of managed lanes the facility operates in each direction. As shown, two lane facilities generate far more than single lanes facilities. Values of time also vary across the country.

It is not possible to quantify the level of revenue that a priced facility in the Nashville region will generate without significant study of the specific facility. However, regardless of revenue generation, the ability to manage capacity – particularly new capacity – maximize its benefits, and preserve it in future years, has a very high value in terms of regional mobility.

Figure 12 — Priced Managed Lanes Revenue, 2011-2013



16 Source: Parsons Brinckerhoff. Figure includes representative managed lanes, and is not an exhaustive list.

Public-Private Partnerships

Public-private partnerships, or P3s, are a growing part of the transportation financing alternatives considered in the United States and internationally, and may be considered in the implementation and financing of managed lane facilities. P3s can take many forms. Among the most common are:

- Developer (or Concessionaire) at revenue risk
- Availability payments
- Developer Financing – short term, less than 10 years

Developer at Revenue Risk

The developer at revenue risk is the P3 model that most often comes to mind. In such cases the developer usually has a long term lease on the facility and is responsible for all aspects of design, construction, and operation within the parameters of the agreement between the developer and the agency that owns the facility, often the state DOT. The sole compensation to the developer comes through the toll revenue stream. A current example is under development by North Carolina to implement managed lanes on I-77. Through this project it is anticipated that priced managed lanes will be added in each direction on I-77 in the Charlotte metropolitan area. Two lanes will be added on most of the facility, dropping to a single added lane further from the city.

Leases are usually very long term, i.e. they are commonly negotiated for 30 to 50-year periods or even longer. There are two primary reasons for the length of such leases. First, since the developer is repaid through tolls collected, it is often necessary for the project to become fully mature in order for the developer to realize a reasonable profit. Second, there are tax regulations that require a lease to be held a certain period of time for depreciation to be allowed. For a private developer, the value of available depreciation can be a significant factor in valuing the project.

Availability Payments

Projects that use availability payments are the same as Developer at Revenue Risk, with one major exception. In the Availability Payment model, the owning agency provides periodic payments to the concessionaire based on a set payment schedule. Under this model, the owning agency accepts the revenue risk as the concessionaire is paid regardless. I-595 in Southeast Florida is an example of the Availability Payments model. The I-595 project is complete and added three reversible managed lanes to the facility. I-595 is also one of the relatively few managed lanes projects to allow large trucks on the facility.

Developer Financing

Under developer financing, the developer agrees to bring in financing for the project. Like the Availability Payments model, the developer is repaid on an agreed timetable. Usually this type of financing has a shorter repayment schedule than availability payments. The I-285/SR 400 interchange in Atlanta is anticipated to use this model. The I-285/SR 400 interchange north of the city of Atlanta proper has been called the most congested interchange in the state of Georgia. With over 400,000 vehicles per day accessing the facility, the interchange will greatly benefit from planned collector-distributor roads and improved ramp configurations.

Eligibility, Benefits, Indicators, and Issues

HOV Lanes

Description and Eligibility

High Occupancy Vehicle (HOV) lanes were among the first managed lanes concepts to be developed. The primary tools used to manage HOV lane use are eligibility and access. HOV eligibility restricts lane use to vehicles with a minimum number of persons traveling in each vehicle. Access is sometimes restricted to specific access or egress points in order to manage demand and promote better traffic flow. An example is shown in Figure 13. [17]

Figure 13 — HOV Lanes in Virginia

Benefits

HOV lanes allow more efficient vehicles in the traffic stream – including those carrying more than one person or emitting a significantly lower amount of pollutants – to benefit from a faster flowing lane than the adjoining general-purpose lanes. This encourages carpooling, purchase of lower emission vehicles, and usually results in a higher per-lane person throughput than adjoining general-purpose lanes.

Indicators

- Adjacent general purpose lanes are heavily congested during peak periods.
- Sufficient demand exists among transit and rideshare users to justify a dedicated lane.
- Travel benefits are enough to cause solo commuters to shift to transit or ridesharing.
- Resources are limited for expanding roadway capacity to meet future demand conventionally.

Issues

Public perception of HOV lanes has generally been positive. The greatest challenge to their acceptance is "empty lane syndrome," when the HOV lane appears to have significant excess capacity while general purpose lanes are severely congested. This can create public concern (perceived or actual) that the roadway is not operating efficiently. In some cases, there is in fact a relatively low number of HOVs and they are not able to use all of the lane's existing capacity. Of course, a properly functioning HOV lane can also appear somewhat "empty" because of the greater separation between high-speed vehicles than those in the lower speed general-purpose lanes. As automated vehicle occupancy enforcement has not been perfected, there is a significant need for manned enforcement in the lanes, which can significantly increase operating costs.

[17] Source: Virginia DOT

The most significant challenge in using HOV lanes for roadway management is that occupancy requirements are a somewhat blunt tool for fine-tuning traffic demand. In a fast-growing region, it is very possible for HOVs to overwhelm the capacity of an HOV lane, resulting in the same lower speeds and reduced capacity being experienced in the adjacent general purpose lanes. However, increasing the eligibility requirements from two occupants to three occupants may quickly turn a congested HOV lane into an underutilized HOV lane.

HOT Lanes

Description and Eligibility

A High Occupancy Toll (HOT) facility is a HOV lane or roadway which may also be used by Single Occupant Vehicles (SOVs) if they pay a toll. An example is shown in Figure 14. [18]

HOT lanes are derived from the concept of congestion pricing, which recognizes that the value of travel-time savings will vary for trips at different times of the day, and that trips have different values for different individuals. These different trips have a real and perceived value of time savings for any given driver; however, tolls will rise as the demand for use of the lane increases.

Figure 14 — HOT Lanes In Minnesota

Depending upon that self-identified value of time, commuters may elect to purchase their way into a non-congested roadway (saving time) or choose to remain in the general purpose lanes (saving money), thus providing drivers a choice.

Benefits

HOT lanes allow the vehicle capacity of the lane to be more easily balanced. They maximize the utility of an HOV lane by "selling" the capacity that remains after the HOV demand has been satisfied. HOT lanes also provide a revenue stream to help offset their overall operating costs, and on occasion, a small amount of additional revenue.

Indicators

- The HOV facility's adjacent general purpose lanes are heavily congested during peak periods.
- Significant excess capacity exists on the HOV facility, even at its peak utilization, or significant excess capacity will be created by increasing occupancy requirements on HOV lanes that are over capacity. It should be noted that an HOV2 lane that is over capacity will need to be adjusted to an HOV3 lane to maintain needed operational efficiency regardless of any HOT conversion. If HOT conversion is contemplated, the need to raise the occupancy level regardless of HOT conversion must be clearly demonstrated to drivers, so that the perception the change is being made solely for revenue purposes is shown to be unfounded.

[18] Source: Minnesota DOT

- Resources are limited for either expanding roadway or transit capacity.
- The public is concerned by low utilization of the HOV lanes.

Issues

In general, the public acceptability of HOT lanes is improving as more facilities are opened across the United States. However, opposition still exists. While extensive data has shown that HOT lanes are used by members of all economic strata, there is still some perception of HOT lanes as "Lexus Lanes" that benefit only the affluent. An effective public outreach program presenting the facts relating to issues with HOT lanes significantly increases public approval. Public support also tends to increase significantly after the opening of the facility, when the benefits can be fully understood through use.

Express Lanes

Description and Eligibility

"Express" lanes do not have the same definition in all areas of the country. Express lanes may mean simply lanes that are set aside with relatively few access points to allow through trips to be separated from local trips. No toll is charged.

For purposes of this assessment, an "express lane" refers to any lane in which all vehicles are required to pay a toll regardless of whether or not there are a limited number of access points. Exceptions might be granted for transit buses, emergency vehicles, and perhaps some public utility vehicles. Tolls are collected from all other vehicles regardless of occupancy or level of emissions. Trucks and other large vehicles (other than transit) are often precluded from using express lanes, but this is not universal.

Benefits

Express lanes have some of the benefits of HOT lanes and two major benefits that HOT lanes do not have. If maximizing revenue from the facility is of prime concern, express lanes will produce more revenue than a HOT lane in the same location, as all vehicles (with the likely exception of buses) are required to pay tolls. Also, express lanes are more easily enforced. Toll enforcement has become straightforward using photo enforcement and/or license plate recognition for tolling vehicles without a transponder. Unlike HOT lanes, in express lanes, no vehicle occupancy enforcement is required. Vehicle occupancy enforcement is much more difficult than toll enforcement. Non-tolled vehicles that are allowed to access the express lane can either be issued a non-revenue transponder, or can be easily identified (as a bus) during the photo enforcement process.

Indicators

- The express lane facility's adjacent general purpose lanes are heavily congested during peak periods.
- The potential express lane is newly constructed capacity and not a conversion of an existing HOV or HOT lane.
- Resources are limited for either expanding roadway or transit capacity.
- Revenue is a prime consideration.

Issues

Conversion of an existing HOT or HOV lane to an express lane can generate significant backlash from the public, particularly from vehicles that were previously accessing the lane due to occupancy or a low emission vehicle type. The perception (and sometimes the reality) is that the previous users are losing a significant benefit so that the facility can generate additional revenue. Even in cases where an HOV facility has so much demand that a change in operational parameters is needed, conversion to an express lane may not be the best strategy, and raising the HOV occupancy requirement may be the better approach. Even in cases where new capacity is used as an express lane, it is possible that the "Lexus Lane" argument will gain additional traction. This can often be offset if a portion of the revenue generated goes to transit service.

Reversible Lanes

Description and Eligibility

Reversible lanes have two major sub categories: contraflow and reversible lanes. *Contraflow lanes* are developed by taking one lane from the off -peak direction of a facility, and marking it for use in the peak direction of travel. Particularly on limited access facilities, the use of a movable median barrier is required. Specialized vehicles (Figure 15) [19] are able to move the barrier into the appropriate location depending on traffic demand and time of day. Contraflow lanes do not need to have any eligibility limits or tolls, but some areas may opt for such policies. Somewhat more common are facilities where the entire facility flows in one direction in the morning peak and in the opposite direction in the afternoon peak (see Figure 16).[20] These are referred to as *reversible lanes*.

Figure 15 — "Zipper" Truck in Honolulu

Either contraflow lanes or reversible lanes may include a specific type of vehicle eligibility or toll payment, but do not need to. Since reversible lanes do not remove any capacity from the off-peak direction, the directional split is not as important as it is with contraflow lanes. However, reversible lanes are still best deployed in areas with particularly heavy directional splits.

Benefits

The primary benefit of contraflow lanes is their ability to provide additional capacity in the peak direction without the addition of new lanes on the facility. Particularly in areas with restricted right-of-way, this can be a major advantage. In the design of new facilities, incorporating the capability for contraflow lanes can provide significant flexibility in meeting future peak direction demand.

The major benefit of reversible lanes is their ability to provide peak direction capacity when it is needed in both directions, using half as many lanes as it would take to provide full-time capacity in both directions.

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[19] Source: Hawaii DOT
[20] Source: FHWA

Indicators

- There is heavy congestion in the peak direction of flow during peak operating hours.
- For contraflow lanes, there is significant *directional split* during the peak operating hours. This generally means that during the morning peak, the inbound (into the city or employment centers) direction has a high demand and the outbound direction has a low demand, and during the afternoon peak the pattern is reversed.
- For reversible lanes there should also be a significant directional split during the peak operating hours. However, the directional split does not need to be as significant as with contraflow lanes, since no capacity is being removed from the off peak direction.
- Resources are limited for either expanding roadway or transit capacity.
- Peak periods are well-defined with sufficient off-peak periods to allow reversing the lane.

Issues

As can be imagined, contraflow lanes are operationally more complex than other managed lanes options. This means higher operating costs; however, using movable concrete barriers, safety does not appear to be a significant issue.

Reversible lanes tend to have a higher operating cost than lanes that maintain the same direction of traffic flow at all times. However, the costs are not as high as with contraflow lanes, since only the entrances and exits need to be reconfigured. Further, this reconfiguration can usually be done remotely, or with minimal manual assist. The mechanisms for reversing the lane, as well as blocking entrances against wrong way movements are well-established.

Figure 16 — Reversible Lane on the Northwest Expressway, Houston, Texas

The potential downside for reversible lanes is the physical configuration of overpasses and bridges. Center piers on existing overpasses can significantly reduce the economy by providing lanes in one direction only. If major bridge reconstruction would need to occur, the marginal cost of providing additional lanes in both directions may be relatively low.

Hard Shoulder Running

Description and Eligibility

Hard shoulder running (HSR) involves opening the roadway shoulder (Figure 17) [21] to allow it to be used as a travel lane. It may or may not be tolled, and use may be restricted to specific vehicles such as buses, or may be open to all vehicles, perhaps with the exclusion of large trucks.

Hard shoulder running should be employed only at times that the general-purpose lanes are slow and congested, and typically they should operate at speeds not exceeding 35 mph. For this reason, hard shoulder running should be accompanied by other advanced traffic management (ATM) strategies including dynamic lane assignment, as well as dynamic speed limits unless the shoulder that is being opened is a very short length, such as might be the case if a shoulder were opened for use at a point just prior to an existing exit ramp.

Figure 17 — Bus on Shoulder on Minneapolis, Minnesota

Benefits

HSR, if full width and full depth shoulders are available, can be implemented for far less expense in a far shorter time than strategies that require the addition of one or more new lanes. Even if the pavement structure on the shoulders must be reinforced, hard shoulder running can be a relatively inexpensive option.

Indicators

- General purpose lanes are heavily congested during peak periods.
- Sufficient shoulder width, and preferably pavement depth, exists to provide safe travel for the intended vehicle and the intended driver without undue degradation of the pavement.
- Resources are limited for conventional expansion of roadway capacity to meet future demand.

Issues

HSR can be an exceptionally efficient way to add capacity during peak demand. However, shoulders are not usually designed to carry high-speed traffic; therefore, speed limits on shoulder should be substantially lower than those for the general-purpose lane. Also, if shoulders are being used to carry active traffic, they become unavailable for breakdowns or use for other emergency situations. It is for these two reasons that hard shoulder running should be deployed along with other ATM

[21] Source: Minnesota DOT

strategies, specifically including variable speed limits/harmonization and dynamic lane assignment.[22]

In some cases refuge areas can be provided to handle breakdowns and other emergency situations. Since these refuge areas do not need to be continuous, it is often possible to provide them in locations where a small amount of additional right-of-way is available and at a much lower cost than providing an additional lane. Where it is not possible to provide refuge areas, the decision must be made whether it is better to use the shoulder for additional traffic capacity – realizing that it may sometimes need to be closed due to a crash or other emergency – than not to make the shoulder capacity available at any time.

Truck Only Toll Lanes

Description and Eligibility

As the name implies, truck only toll lanes (TOT lanes), are special purpose toll lanes exclusively for use by large vehicles, usually described as vehicles with more than two axles, including trailers. Commercial vehicles, particularly large trucks, traditionally have a much higher value of time than single occupant vehicles. Efficient truck movement is important not only to individual shippers and receivers, but has broader economic importance due to the rising use of just-in-time delivery. However, at this time no TOT lanes have been implemented in the United States.

Benefits

The benefits of TOT lanes are centered on providing the unhindered movement of freight with reliable travel times. Separating large vehicles from the general traffic stream may also produce some safety benefits and can reduce congestion for other traffic. Finally, the tolling aspect of TOT lanes can allow the full impact of heavy vehicle use on the physical infrastructure to be taken into account.

Indicators

- There is a large percentage of trucks, particularly trucks with more than two axles, in the traffic stream.
- There is significant congestion in the peak direction.
- The majority of trucks in the traffic stream are long-haul versus local delivery.

Issues

There are no operating truck toll lanes in the United States, which complicates the potential to determine issues based on actual experience. The issue confronting planners is likely to be whether capacity is best used by devoting it to larger vehicles or to general-purpose vehicles in the traffic stream. Microsimulation modeling is likely the best mechanism for this to be analyzed. Because of

[22] As shown previously in Figure 3, if HSR is implemented, dynamic speed limits/speed harmonization allows speeds to be set at a safe limit for shoulder operation (usually lower speeds than in regular travel lanes). Dynamic lane assignment allows the shoulder to be opened or closed to traffic; it also provides a mechanism for traffic management during periods when regular travel lanes must be shut down due to crashes, other incidents, or construction. As was also shown in Figure 3, dynamic lane assignment can be used to designate certain lanes as special use lanes and vary that use over the day as conditions change.

Nashville's position as a major freight hub, there could be some merit for the evaluation of a TOT lane.

Ramp Metering

Description and Eligibility

Ramp metering is a lane management strategy that is focused on all lanes on the facility, not just special use lanes (Figure 18). [23] Ramp metering works by using a red/green traffic signal located on the ramp to manage the flow of vehicles onto the main facility. This enables the overall traffic density, evaluated in vehicles per mile, to be reduced. By maintaining traffic density in an ideal range, operating speeds, travel time reliability, and vehicular throughput is maximized.

Ramp metering can be implemented for all vehicle types. In some cases, a lane to bypass the queue is developed on the ramp to allow HOVs, buses, and sometimes trucks to bypass the queue as these vehicles have a higher value of time than a typical general-purpose vehicle because of their occupancy, or the freight being carried.

Figure 18 — A Dual Lane Ramp Meter

Benefits

The benefits associated with ramp metering are highly dependent on how ramp metering is implemented. Ramp metering has the proven ability to dramatically improve travel conditions and vehicular throughput on major urban freeways. To be most effective, all entrance points that could impact the areas of recurring congestion must be metered, the meters must be closely coordinated with each other, and there must be sufficient storage for vehicles waiting to enter the facility.

Indicators

- The facility's general purpose lanes are heavily congested during peak periods.
- Ramps are able to accommodate the necessary vehicle storage, or sufficient storage can be provided.
- Resources are limited for either expanding roadway or transit capacity.
- The public is concerned by traffic congestion and there is a significant desire among the traveling public to relieve congestion and improve travel time reliability.

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[23] Source: FHWA

Issues

There are two major issues involved in ramp metering. The first is public perception. As it is counterintuitive that delaying entry for a vehicle on the ramp actually provides a shorter overall trip time, public education of how ramp metering works and why it is effective is critical. The second issue is vehicle storage. If ramps do not have sufficient storage space, queues to enter the freeway facility can back up onto adjacent arterials. Although the entire roadway system may actually operate more efficiently if this is allowed to happen, public sentiment usually runs strongly against this approach. Vehicular storage that does not interfere with arterial operation must therefore be provided to obtain the maximum effectiveness from ramp metering. This can be expensive, but is likely less expensive than adding additional lane capacity.

Truck Restricted Lanes

Description and Eligibility

As the name implies, truck restricted lanes are simply lanes on the facility which do not allow large trucks (Figure 19). [24] The restriction is generally based on number of tires or number of axles. Signage indicating that trucks of a certain type are only permitted in – for example – the right two lanes would represent an example of truck restricted lanes. As noted earlier, this type of lane management is already in practice in Tennessee.

Figure 19 — Truck Lane Restrictions during Specified Hours

Benefits

Although many citizens perceive truck restricted lanes as a safety measure, their primary benefit relates to trucks' ability to accelerate and decelerate. Particularly in hilly or mountainous regions, smaller vehicles are able to accelerate much more quickly than a large heavily loaded truck. Providing one or more lanes from which trucks are restricted can therefore allow traffic to flow more efficiently.

Indicators

- There is a large percentage of trucks, particularly trucks with more than two axles, in the traffic stream.
- The facility is in a hilly or mountainous region.
- There is evidence of trucks interfering with smaller vehicle operation.

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[24] Source: FHWA

Issues

Truck restricted lanes exist throughout the United States. When properly applied, few issues exist as long as at least two lanes are available for large trucks so that they can pass each other if and when necessary.

Transit Only Lanes

Description and Eligibility

As the name states, transit only lanes are devoted completely to transit vehicles. This is the rubber-tire equivalent to rail. In some areas, registered carpools may also be allowed. Some HOV lanes in the United States began as transit only lanes, such as the Shirley Highway Express Bus on Freeway program in 1976 in Virginia. Perhaps the most successful bus lane is on I-495 in New York (Figure 20) [25] where during peak hours all of the available capacity is consumed by transit vehicles. For many facilities, however, a decision was ultimately made to evolve them into HOV or HOT lanes.

Figure 20 — I-495 Bus Lane, New York

Benefits

Transit only lanes provide the greatest advantage for transit vehicles over other vehicles in the general-purpose lanes. This certainly includes increased schedule reliability, which has been identified as a major issue for urban travelers. The increased visibility of transit benefits may also help attract choice riders in addition to the transit dependent. There is also the potential for increased service frequency, but that will be highly dependent on the availability of operating funds. Some operating funds come from the farebox, but in the U.S., state and local sources are also needed.

Indicators

- The facility's general purpose lanes are heavily congested during peak periods.
- Capital and operating funding is available to expand transit service to take advantage of the transit lanes.

Issues

It is highly unlikely sufficient transit demand, or need, could ever completely utilize the capacity of a standalone transit only lane. For example, on a limited access facility, a transit vehicle would need to pass every 2 to 3 seconds and every 4 to 6 seconds on an arterial for full lane utilization. Assuming a 40 passenger bus is the transit vehicle, this would mean that there would need to be a demand of at least 48,000 persons per hour utilizing transit on one segment of limited access highway, and approximately half of that for an arterial. As this level of demand is unlikely to exist, transit only lanes likely leave a significant amount of valuable capacity unused.

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[25] Source: FHWA

Transit in the Managed Lane Environment

Description and Eligibility

Transit has an exceptionally high level of synergy with managed lanes. Transit vehicles can be allowed to utilize the benefit of any type of managed lanes strategies to provide the same level of service that a transit only lane could provide. In fact, Bob Poole of the Reason Foundation coined the term "Virtual Bus Lane" to describe a managed lane that provides the same benefit to transit as an exclusive lane, but that also allows other drivers to utilize the lane based on occupancy requirements or payment of toll. By managing demand in the lane, minimum operating speeds are guaranteed, and the full capacity of the lane is utilized. This results in an exceptionally efficient use of available capacity.

Benefits

Transit receives the benefit of a special transit lane by using proven lane management principles to maintain operating speeds while fully utilizing all lane capacity in an efficient manner.

Indicators

- Any time a lane management strategy is being considered, the ability of transit to take advantage of the strategy should also be considered.

Issues

Practically all issues associated with transit in the managed lanes environment are positive. If properly implemented it is unlikely that there will be any significant negative issues associated with transit in the managed lane environment.

Defining the Goals for Exploring Managed Lanes in the Nashville Region

Across the nation, typical goals for implementing managed lanes include, but are not limited to:

- Maintaining mobility;
- Improving roadway operation efficiency and reliability;
- Promoting transit and ridesharing;
- Improving safety;
- Providing travel options to meet user needs, such as “time-sensitive” travel;
- Generating revenue to offset capital and operating expenses; and
- Improving air quality.

Objectives for managed lanes can be region and/or facility specific, including:

- Increasing person-moving capacity of the roadway;
- Promoting transit and ridesharing mode split;
- Optimizing vehicle-carrying capacity;
- Promoting travel-time savings, reliability, or efficiency for selected travel modes;
- Improving air quality by increasing ridesharing and transit as part of a conformity plan;
- Increasing funding opportunities for new mobility improvements;
- Enhancing existing transit investments and services in the region/facility;
- Providing a greater choice in serving multimodal needs (people, goods, services);
- Improving the movement of commerce (goods and services); and
- Supporting community land use and development goals, particularly to major areas of employment.

Fundamental to these goals and objectives is an implicit set of conditions that should exist for managed lanes to be considered viable. These conditions include the following:

- A recurring congestion problem with traffic operating at level of service “D” or worse within a corridor or region for a significant period of time each weekday;
- A significant backlog of unmet travel demand, and/or lack of available resources (right-of-way, funding, regional consensus or environmental issues) to address capacity deficiencies in a more conventional means through adding roadway or transit capacity; and/or
- An interest and ability to minimally increase roadway capacity by managing its use to specific dedicated purposes to ensure that a high level of service can be provided as an alternative to recurring congestion.

Goals

Goals of a managed lanes strategy can be integrated into the MPO's broader policy framework for the Regional Transportation Plan. Potential goals of a managed lanes strategy, shown in blue, are listed along with other RTP goals adopted by the MPO.

Maintain a Safe and Reliable Transportation System for People and Goods

- Integrate a "fix-it-first" mentality to keep existing infrastructure in a state of good repair.
- Reduce the number and severity of crashes by designing roadways to accommodate all users.
- Incorporate information technologies to improve traffic operations and help optimize traveler decisions.
- Manage the negative impact of traffic congestion by providing alternatives to driving.
- Designate and implement a regional freight network to efficiently move goods and minimize negative impacts to local communities.
- Improve traffic operations and optimize travel through the ***use of technology*** that enables dynamic response to roadway conditions.
- Build awareness of the purpose and value of managed lanes in the Nashville region to ensure that ***legitimate users receive the full benefits*** of a managed lanes system.

Help Local Communities Grow in a Healthy and Sustainable Way

- Align transportation decisions with economic development initiatives, land use planning, and open space conservation efforts.
- Integrate healthy community design strategies and promote active transportation to improve the public health outcomes of the built environment
- Encourage the deployment of context-sensitive solutions to ensure that community values are not sacrificed for a mobility improvement.
- Incorporate the arts and creative placemaking into planning and public works projects to foster innovative solutions and to enhance the sense of place and belonging.
- Pursue solutions that promote social equity and contain costs for transportation and housing.
- Minimize the vulnerability of transportation assets to extreme weather events.
- Protect regional air quality through transportation management tools that provide incentives for more ***environmentally sound travel choices***, such as ridesharing and transit.
- Manage travel demand on major roadways in a way that ***maintains affordable transportation options*** for all users.

Enhance Economic Competitiveness to Attract Private Investment

- Recognize major shifts in demographics and market preferences for transportation and housing and respond with solutions that keep Middle Tennessee an attractive place to live and do business.

- Improve the connectivity between workforce and jobs by offering a range of options to manage commuting distances and travel times.
- Improve mobility within and between centers of commerce across the region by providing a diversified transportation system, rather than relying solely on roadway capacity.
- Keep the region connected to national and global markets by improving travel times on US Interstates, upgrading intermodal connections to water, air, and rail freight systems, and by ensuring Middle Tennessee is included in plans for national high speed passenger rail.
- ***Preserve Middle Tennessee's economic advantages*** by ensuring that travel on major highways is sufficiently reliable for the needs of freight movement to, from, and through the region.
- ***Improve travel time and reliability for transit riders*** by providing a comprehensive managed lanes system for use by regional/express transit services.

Spend Public Funds Wisely by Ensuring a Return on Investment

- Increase public ownership in the planning process to help identify the most significant problems.
- Foster regional interdisciplinary collaboration to prioritize the most effective solutions.
- Evaluate the full costs and benefits of public investment in infrastructure.
- Strive for quality over quantity by implementing all elements of priority projects to maximize value.
- Consider public-private partnerships to encourage innovative approaches to project design and delivery.
- Accelerate project delivery schedules by involving the public early and often, minimizing bureaucratic delay, and ensuring that funding is available to implement projects once designed.
- Monitor and track the performance of public investments to demonstrate accountability.
- Find ways to bridge the gap between revenue shortfalls and the growing cost of transportation needs.
- Use available roadway capacity to move a greater number of people by ***supporting efficient travel options*** such as carpools, vanpools, and transit.
- ***Generate revenue*** for maintenance, operations, and additional improvements to the transportation network.

Challenges in Implementing Managed Lanes in the Nashville Region

Nearly all transportation projects face challenges in development and implementation, and managed lanes are no exception. These can include financing, right-of-way, public support, and the benefits to be achieved, among others. In addition to these common challenges, each metropolitan area has its own specific issues that must also be addressed. In the Nashville region, this may include:

- *Multijurisdictional responsibility for the highway system*

  Traffic operations on the region's freeways and major arterials are operated independently by separate agencies, complicating the assessment and implementation of many of the alternatives as well as requiring agreement by the appropriate operating agencies.

  TDOT has responsibility for traffic management and operations on freeways in the Nashville region. This includes not only the interstate corridors but also US 31E / SR 6 (Ellington Parkway), SR 155 (Briley Parkway), SR 386 (Vietnam Veterans Parkway), and SR 840. On the region's arterial roads, traffic management and operations are primarily handled by local jurisdictions, with coordination with TDOT on particular issues such as signal installation and permits for new accesses.

  Implementing certain transportation system management tools, such as ramp metering, may require choices between improving traffic flow on freeways while creating some adverse impacts to arterial traffic flow. Other improvements, such as transit improvements to take full advantage of other management improvements would also involve multiple agencies and/or jurisdictions. Close coordination on many issues would therefore be needed between TDOT, other affected agencies, and local governments.

- *The Inner Loop*

  The Inner Loop is the historic core of the highway system in Nashville and includes three major interstates that merge and diverge over a relatively short distance within a mature downtown. There are multiple locations on the Inner Loop where many drivers must weave across two or more lanes in order to choose the interstate needed to exit the Inner Loop in the desired direction. The use of the existing lanes for interstate-to-interstate weaving maneuvers reduces the feasibility of converting general-purpose lanes and adds to the complexity of designing any new lanes to which access would be managed. Grade separation of the interstate-to-interstate interchanges has been discussed in MPO plans for the past 30 years, and perhaps management of those facilities would assist in the feasibility of developing this type of system. However, it would remain very costly, and the issue has remained unaddressed as major interstate improvements have been called for in other parts of the Nashville region experiencing rapid growth.

  The Inner Loop also includes several major structures – such as the two Cumberland River bridges – which make it less feasible to add managed lanes by widening into the median. (For more detailed discussion of physical conditions on each corridor, see the section on Constructability of New Facilities.)

  The complex issues of the Inner Loop cannot be solved through management techniques alone. A comprehensive study on the Inner Loop, including its impact on the region as a whole and on downtown Nashville in particular, is needed prior to any major decisions involving managed facilities, other than the HSR strategies (which will need additional study to fully understand feasibility) suggested here as a near-term action.

- *Enabling legislation* will likely be needed at the state level, as discussed later.
- *Federal legislation* may or may not be needed.
- It is unlikely that priced efforts will yield enough revenue to cover all of the capital and operating costs involved. *Additional funding sources* will need to be identified.
- Depending on alternatives chosen, *significant reconstruction of existing facilities* may or may not be needed.
- *High violation rates* on existing HOV facilities.

Agency considerations are not insurmountable and have been successfully addressed in other areas. The key to successful project implementation is early and continuing coordination with all agencies involved as well as the public. This ensures all needs and goals are taken into account early in the development process, when they can be best resolved.

As with agency coordination, the key is early recognition of the issue, preferably as multiple strategies are being considered. In fact, a major selection factor for any managed lanes strategy should be its ability to minimize or mitigate these challenges.

There may be issues relating to cost sharing, operations, and possibly liability that will also need to be taken into account. So long as discussions begin early in the process, it is highly likely that all issues can be successfully addressed.

The high density of converging/diverging interstate facilities in the Nashville region is a significant issue that must be addressed in project development. Any managed lanes strategy considered will require careful consideration of how each interstate facility impacts the others.

For example, a ramp metering strategy must evaluate how metering on one facility will impact other facilities, whether metered or not. Likewise, if HOV lanes are implemented on one facility, and HOT lanes on another, how will information be transmitted to drivers so that they understand the various eligibility requirements and charges? All strategies that may be considered for the Nashville region will have similar issues, and allowing drivers to move from one facility to another while operating under managed conditions will bring its own set of challenges.

Legislative issues will depend upon the strategies that are pursued. It is very unlikely that there would be "fatal flaw" legislative issues, in terms of the ability to legislate needed powers to enact specific projects. However, there may be issues with the political realities of some requirements. To use an extreme example -- and one that is not recommended – it may be possible to pass a law that establishes days and times when drivers may access the urban core based on whether they have even or odd license plate numbers, but such a law is likely not politically feasible.

The high violation rates on existing HOV facilities could also create a challenge in converting these facilities to HOT. These include issues relating to little incentive to pay a toll when access is not truly restricted to HOVs, and the lack of available capacity for tolling to occur. As noted later in the section on Policy and Legislative Considerations, TDOT has indicated it is evaluating these issues and plans to take steps to address them.

Existing HOV Facilities in the Nashville Region

The region's managed lanes system currently includes approximately 128 lane-miles (the total distance of all applicable travel lanes), all of which is designated HOV. Table 2 lists the existing HOV lane termini and length in lane-miles for the Nashville region.

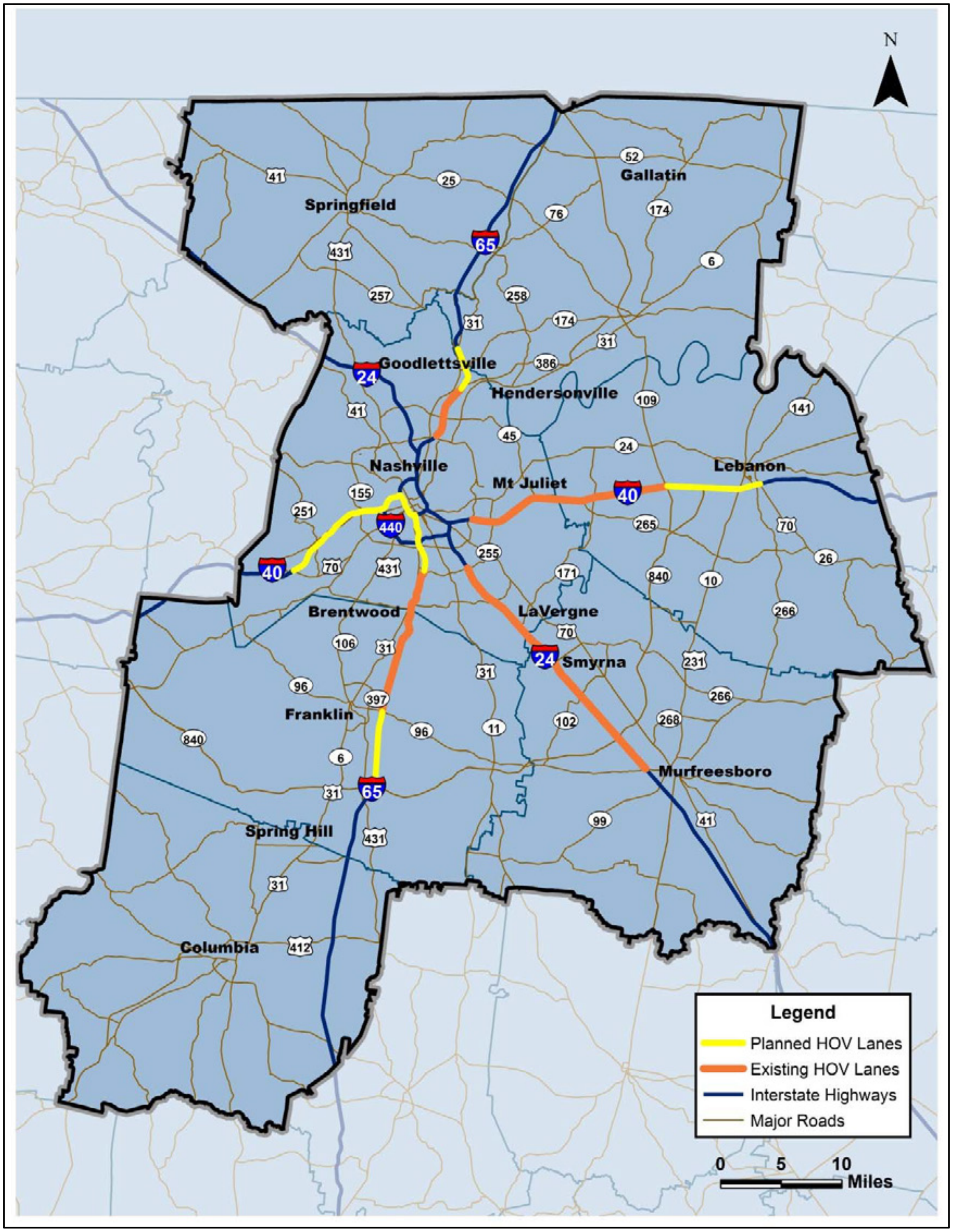
Table 2 — Existing HOV Lane Termini and Length

Route (Location)	Begin HOV Lanes	End HOV Lanes	Distance (Lane-Miles)
Interstate 24 (East of Nashville)	Exit 56 (SR 255, Harding Place)	Exit 81 (US 231, Shelbyville Highway)	50
Interstate 40 (East of Nashville)	Exit 215 (SR 155, Briley Parkway)	Exit 232 (SR 109)	34
Interstate 65 (North of Nashville)	Exit 90 (SR 155, Briley Parkway)	Exit 95 (SR 386, Vietnam Veterans Parkway)	10
Interstate 65 (South of Nashville)	Exit 61 (SR 248, Peytonsville Road)	Exit 78 (SR 255, Harding Place)	34

Additionally, the widening of Interstate 65 south of Nashville from State Route 840 to State Route 248 (Peytonsville Road), projected for completion in summer 2016, will extend the existing HOV lane terminus to State Route 840, adding approximately 4 lane-miles to the existing system.

All of the existing HOV facilities are immediately adjacent to the general purpose lanes. This is by far the most common configuration nationally. The HOV lanes are identified by pavement markings consisting of a white skip line and standard HOV diamonds, as well as posted signs indicating the minimum required occupancy (2+ persons) and the hours of operation (7:00 AM – 9:00 AM and 4:00 PM – 6:00 PM on weekdays). On recent construction projects that have integrated HOV lanes, such as the widening of I-40 east of Mount Juliet, the state has also installed signage to indicate the HOV lane may be used by inherently low emissions vehicles (ILEVs).

Figure 21 — Existing HOV Lanes in the Nashville Region



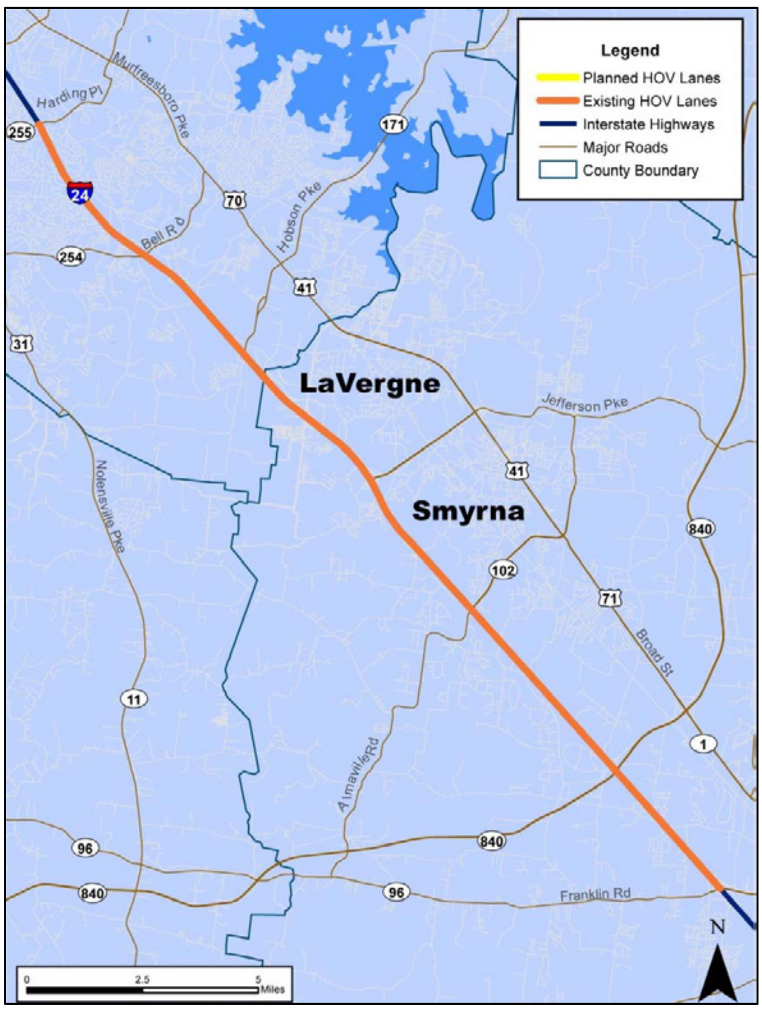
Interstate 24

HOV lanes currently exist along Interstate 24 east of Nashville from the State Route 255 (Harding Place) interchange (Exit 56) in Davidson County to the State Route 10 (US Route 231, Shelbyville Highway) interchange (Exit 81) in Rutherford County, a distance of approximately 25 miles.

Interstate 24 features eight travel lanes along the entire length of this segment, with each direction featuring three general-purpose lanes and one HOV lane; the segment features a total of 50 lane-miles of HOV facilities. Hours of HOV lane operation are weekdays from 7:00 AM – 9:00 AM in the westbound direction and 4:00 PM – 6:00 PM in the eastbound direction.

The 2013 average annual daily traffic (AADT) along this segment of Interstate 24 varied between nearly 167,000 vehicles per day near State Route 255 (Harding Place) in Davidson County to approximately 75,000 vehicles per day near State Route 10 (US Route 231, Shelbyville Highway) in Rutherford County.

Figure 22 — Existing and Planned HOV Lanes on Interstate 24 East of Nashville



Interstate 40

East of Nashville

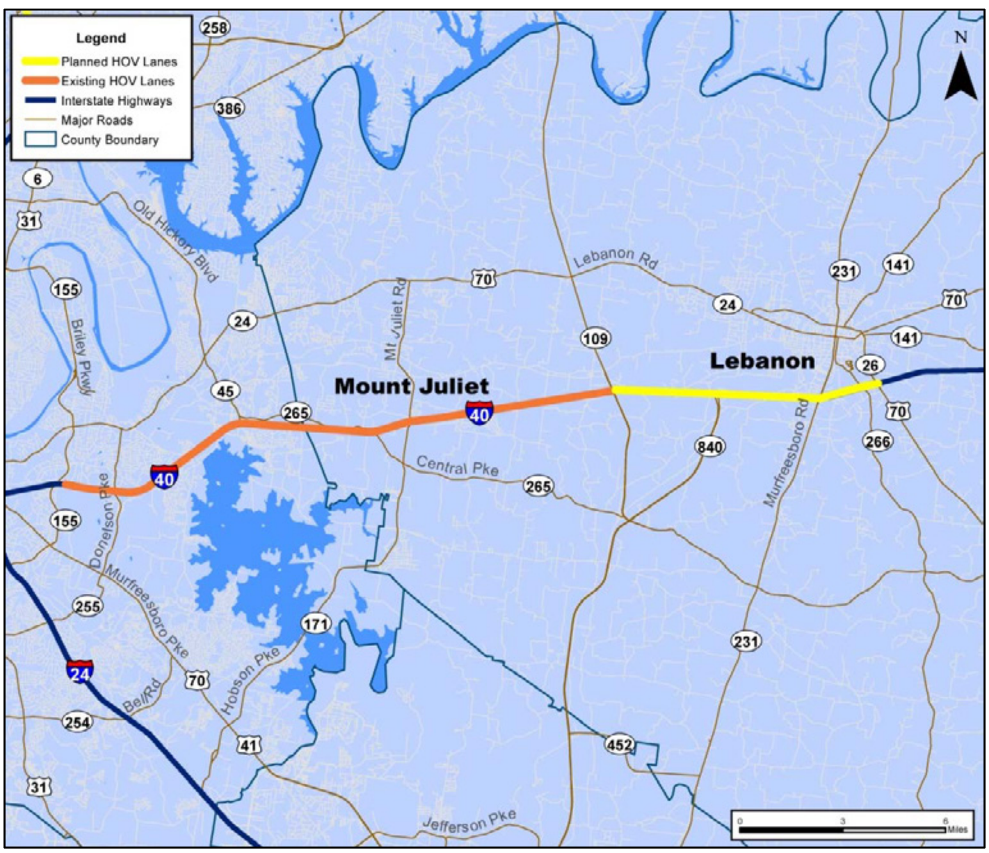
HOV lanes currently exist along Interstate 40 east of Nashville from the State Route 155 (Briley Parkway) interchange (Exit 215) to the State Route 109 interchange (Exit 232), a distance of approximately 17 miles.

Interstate 40 features eight travel lanes along the entire length of this segment, with each direction featuring three general-purpose lanes and one HOV lane; the segment features a total of 34 lane-miles of HOV facilities. Hours of HOV lane operation are weekdays from 7:00 AM – 9:00 AM in the westbound direction and 4:00 PM – 6:00 PM in the eastbound direction.

The 2013 average annual daily traffic (AADT) along this segment of Interstate 40 varied from over 111,000 vehicles per day near State Route 155 (Briley Parkway) in Davidson County to over 71,000 vehicles per day near Beckwith Road in Wilson County.

Additionally, project number 1072-213 in the 2035 RTP, proposed for completion in the 2016 to 2025 timeframe, would widen Interstate 40 to six travel lanes, adding two HOV lanes, from State Route 840 to State Route 26 (US Route 70) in Wilson County, a distance of approximately 6.5 miles. This project would add approximately 13 lane-miles of HOV facilities to the corridor.

Figure 23 — Existing and Planned HOV Lanes on Interstate 40 East of Nashville



West of Nashville

No HOV lanes currently exist on Interstate 40 west of Nashville. However, two projects listed in the 2035 Regional Transportation Plan (RTP) would add approximately 24 lane-miles of HOV facilities to this corridor:

- The widening of Interstate 40 from 6 to 8 lanes between State Route 1 (US Route 70S) and Interstate 440, including the addition of 2 HOV lanes (1012-207, FY 2016–2025); and
- The widening of Interstate 40 from 6 to 8 lanes between Interstate 440 and Interstate 65, including the addition of 2 HOV lanes (1012-208, FY 2016–2025).

Figure 24 — Existing and Planned HOV Lanes on Interstate 40 West of Nashville

Interstate 65

North of Nashville

HOV lanes on Interstate 65 north of Nashville currently exist from the State Route 155 (Briley Parkway) interchange (Exit 90) to the State Route 386 (Vietnam Veterans Parkway) interchange (Exit 95) in Davidson County, a distance of approximately 5 miles.

Interstate 65 features ten travel lanes along the entire length of this segment, with each direction featuring four general-purpose lanes and one HOV lane; the segment features a total of 10 lane-miles of HOV facilities. Hours of HOV lane operation are weekdays from 7:00 AM – 9:00 AM in the southbound direction and 4:00 PM – 6:00 PM in the northbound direction.

The 2013 average annual daily traffic (AADT) along this segment of Interstate 65 varied from over 148,000 vehicles per day near State Route 155 (Briley Parkway) to nearly 144,000 vehicles per day near State Route 386 (Vietnam Veterans Parkway).

Project number 1052-212 in the 2035 RTP, proposed for completion in the 2016 to 2025 period, would widen Interstate 65 north of the existing HOV facilities to eight travel lanes from Rivergate Parkway to State Route 41 (US Route 31W) through Goodlettsville in Davidson and Sumner Counties. This project, approximately 3.5 miles in length, would include two HOV lanes, adding an extra 7 lane-miles to the existing facilities.

Figure 25 - Existing and Planned HOV Lanes on Interstate 65 North of Nashville

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South of Nashville

Limits of the I-65 HOV facility south of Nashville generally extend from SR 96 in Williamson County northbound to Harding Place in Davidson County. Southbound, the HOV facility extends from Armory Drive in Davidson County to SR 96 in Williamson County.

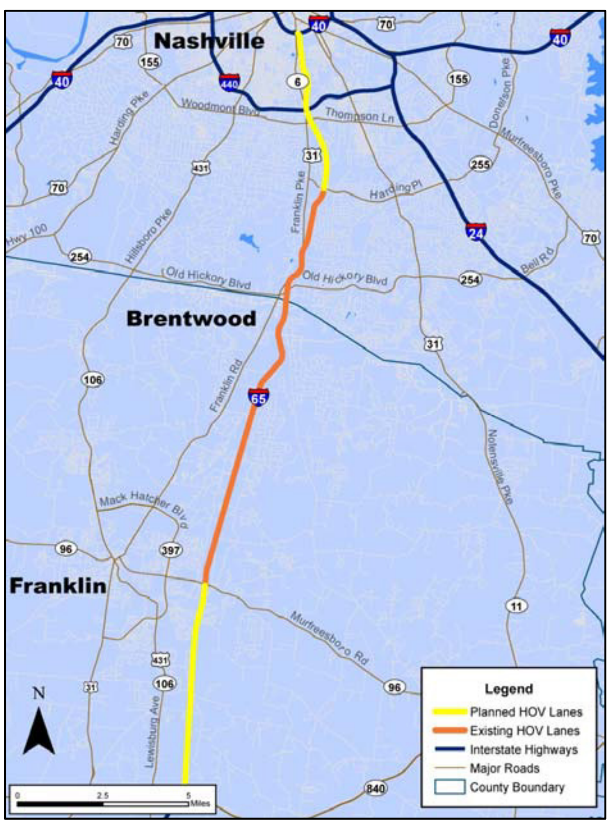
The interstate includes four lanes (a HOV lane and three general purpose lanes) in each direction.

The portion of the HOV facility in Williamson County is 9.4 miles in the northbound direction and 8.8 miles southbound, for a total of 18.2 lane-miles. In Davidson County, the HOV facility is 4.0 miles in the northbound direction and 5.0 miles southbound, for a total of 9.0 lane-miles. Hours of HOV lane operation are weekdays from 7:00 – 9:00 a.m. northbound and 4:00 – 6:00 p.m. southbound.

The widening of Interstate 65 south of Nashville from State Route 840 to State Route 248 (Peytonsville Road), projected for completion in summer 2016, will extend the existing HOV lane terminus to State Route 840, adding approximately 4 lane-miles to the existing system. Additionally, project number 1012-205 in the 2035 RTP, proposed for completion in the 2016 to 2025 timeframe, would modify Interstate 65 to provide eight travel lanes for its full length from State Route 255 (Harding Place) to Interstate 40 in south Nashville. This project, approximately 4.7 miles in length, would include two HOV lanes, adding another 10 lane-miles.

The 2013 average daily traffic along this segment of I-65 in Davidson County ranges from over 162,000 vehicles near I-440 to roughly 151,000 vehicles near the Davidson/Williamson County line. In Williamson County, the average daily traffic along the HOV facility on I-65 was between 146,000 vehicles at Concord Road to roughly 96,000 vehicles near SR 96.

Figure 26 — Existing and Planned HOV Lanes on Interstate 65 South of Nashville



State Route 6 (US Route 31E, Ellington Parkway)

No HOV lanes currently exist on State Route 6 (US Route 31E, Ellington Parkway). However, Project number 2012-218 in the 2035 RTP, proposed for completion in the 2016 to 2025 period, would widen State Route 6 (US Route 31E, Ellington Parkway) to provide six travel lanes along its entire length from North First Street to Broadmoor Avenue in east Nashville, a distance of approximately 4.6 miles. Preliminary engineering and ROW acquisition for this project has been completed.

Although this project does not describe the additional lanes as managed, the *Northeast Corridor Mobility Study*, published by the Nashville MPO in August 2011, suggests a bus rapid transit (BRT) option for movement between Nashville and Gallatin that would utilize transit-only lanes on State Route 6 (US Route 31E, Ellington Parkway) within the area of the proposed project. The proposed lanes might be converted to managed lanes for this option or otherwise while maintaining the existing general-purpose lanes (though constructing a segregated facility would require reconstruction of the four overpassing bridges along the route). However, this conversion is contingent on the ability of the existing lanes to serve projected general-purpose traffic.

Existing Managed Lanes Utilization in the Nashville Region

HOV Lane Utilization and Compliance

In July and August 2012, data was collected on the existing HOV lanes in the Nashville and Memphis regions as part of an effort by TDOT to document the system's operational performance. The data collected included vehicle classification and occupancy traffic counts, as well as travel speeds. Data from this report were the source for information presented below in Tables 3 through 6 as well as Figure 27.

Locations

Table 3 lists the HOV lane data collection locations for the Nashville region. At each location, data was collected from 7:00–9:00 AM for inbound lanes and 4:00–6:00 PM for outbound lanes to match the operation times of the HOV lanes.

Table 3 — HOV Lane Data Collection Locations

<table>
<tr><th>Route</th><th>Exit No.</th><th>Exit Route</th></tr>
<tr><td rowspan="2">Interstate 24
(East of Nashville)</td><td>57</td><td>Haywood Lane</td></tr>
<tr><td>66</td><td>State Route 266 (Sam Ridley Parkway)</td></tr>
<tr><td>Interstate 40
(East of Nashville)</td><td>221</td><td>State Route 45 (Old Hickory Boulevard)</td></tr>
<tr><td>Interstate 65
(North of Nashville)</td><td>92</td><td>State Route 45 (Old Hickory Boulevard)</td></tr>
<tr><td rowspan="3">Interstate 65
(South of Nashville)</td><td>68</td><td>Cool Springs Boulevard</td></tr>
<tr><td>71</td><td>State Route 253 (Concord Road)</td></tr>
<tr><td>74</td><td>State Route 254 (Old Hickory Boulevard)</td></tr>
</table>

Violation Rates

Table 4 lists the observed violation rates, which ranged from 63% to 96%. In other words, 63% to 96% of the vehicles in the HOV lanes were not eligible users. The various impacts of this high violation rate were noted earlier in this assessment.

Table 4 — HOV Lane Observed Violation Rates

Route	Exit No.	Exit Route	Inbound Rate	Outbound Rate
Interstate 24 (East of Nashville)	57	Haywood Lane	89%	80%
	66	SR 266 (Sam Ridley Parkway)	65%	65%
Interstate 40 (East of Nashville)	221	SR 45 (Old Hickory Boulevard)	74%	68%
Interstate 65 (North of Nashville)	92	SR 45 (Old Hickory Boulevard)	96%	94%
Interstate 65 (South of Nashville)	68	Cool Springs Boulevard	71%	63%
	71	SR 253 (Concord Road)	82%	85%
	74	SR 254 (Old Hickory Boulevard)	77%	96%

The high violation rates of HOV lanes in the Nashville region mean that the HOV lanes operate similarly to the general-purpose lanes. As a result, many of the HOV users remain in the general purpose lanes, though the average occupancy of the HOV lanes (1.19 persons per vehicle) does remain slightly higher than the general-purpose lanes (1.10 persons per vehicle). Legal users in the HOV lane comprise about 4% of total traffic in the area, while the number of violators in the HOV lane is over four times greater.

Speeds

Travel speed data was collected for the HOV lanes using the floating-car technique. In this method, a data collection vehicle travels in the traffic stream and obtains the average speed by ensuring that it passes the same number of vehicles by which it is passed. The amount of time required for the data collection car to travel a known distance determines the speed of the traffic stream.

Table 5 lists the recorded speed data.

Table 5 — HOV Lane Recorded Speeds

Route	Location	Inbound Speed (mi./hr.)	Outbound Speed (mi./hr.)
Interstate 24 (East of Nashville)	Davidson Co.	52.0	59.9
	Rutherford Co.	68.3	69.7
Interstate 40 (East of Nashville)	Davidson Co.	59.7	50.0
	Wilson Co.	50.0	59.7
Interstate 65 (North of Nashville)	Davidson Co.	61.2	39.5
Interstate 65 (South of Nashville)	Davidson Co.	66.9	48.4
	Williamson Co.	67.4	61.0

Because of these relatively high speeds, the incentive for drivers to choose a priced alternative is greatly diminished.

Incorporation of Existing HOV Lanes into a Managed Lane Plan for the Nashville Region

Conversion of Existing HOV Lanes

Conversion of the existing HOV lanes to HOT lanes could be a logical first step in the development of managed lanes for the Nashville urban area.

One of the most important elements in considering conversion of HOV lanes into HOT lanes is the availability of existing capacity on those routes. As HOV lanes in Tennessee currently operate with a very high violation rate, certain assumptions are necessary to develop estimates regarding how much capacity would likely be able to be devoted to the HOT lane conversion.

It is assumed in the case shown below that the HOT lane would continue to allow HOV 2+ to travel free. However, it is also possible to convert the HOT lane to HOV 3+.

The capacity available to accommodate drivers paying a toll varies depending on the number of HOVs in all lanes and the percentage of those HOVs that actually use the HOV lane. In a recent sketch-level analysis performed for TDOT, it was assumed that the total number of HOVs observed in the two hours of HOV lane operations (AM or PM peak) is equally divided between the first and the second hour. A more detailed, corridor-specific analysis would consider the peaking that occurs within the peak.

Estimates of the amount of capacity available to sell to single-occupant vehicles were developed. The lower end of the range is based on the assumptions that with no violations, HOV participation will be 100 percent (maximizing the number of HOVs in the HOV lane), and that the desired level of service in the HOV lane means no more than 1,350 vehicles can be accommodated. The upper end of the range assumes that only 90 percent of HOVs will use the HOV lane, and that a maximum of 1,650 vehicles can be accommodated. The results based on this sketch level analysis are shown in Table 6.

Table 6 — Available HOV Capacity[26]

Route	Location	Direction	HOV (veh./hr.)	Min. Add'l Capacity (veh,/hr.)	Max. Add'l Capacity (veh./hr.)
I- 24 (East of Nashville)	Haywood Ln.	Inbound	1,561	0	245
		Outbound	1,522	0	281
	SR 266 (Sam Ridley Pkwy.)	Inbound	709	641	1,012
		Outbound	889	461	850
I- 40 (East of Nashville)	SR 45 (Old Hickory Blvd.)	Inbound	360	990	1,326
		Outbound	727	623	996
I-65 (North of Nashville)	SR 45 (Old Hickory Blvd.)	Inbound	1,102	248	659
		Outbound	1,241	109	534
I- 65 (South of Nashville)	Cool Springs Blvd.	Inbound	720	630	1,002
		Outbound	731	619	993
	SR 253 (Concord Rd.)	Inbound	1,063	287	693
		Outbound	1,388	0	401
	SR 254 (Old Hickory Blvd.)	Inbound	1,102	248	765
		Outbound	1,201	109	105

These results must be treated only as general indicators to guide further study, and should not be the sole basis for any policy decisions. A facility-specific feasibility study would examine changes in operational parameters and perform deeper analysis of conditions on the facility, such as trip length and trip purpose and/or in-depth weave/merge analysis. The additional level of study could result in significantly different conclusions from this screening-level analysis.

In general, it can be said that there is likely to be available capacity beyond HOV needs on many of the facilities. However, there are corridors (such as I-24) that do not appear to have any additional capacity to sell; in fact, they are above capacities that are normally associated with well-functioning HOV lanes. If all eligible HOV users on corridors currently carrying 1,350 or more HOVs were to access the HOV lane, it is possible that the resulting congestion from HOV use alone would significantly degrade the HOV facility performance. In these cases, conversion of the corridor to HOV 3+ may need to be considered.

Incorporating Transit Benefits into HOV or HOT

Managed lanes in the Nashville region could offer a significant opportunity to implement portions of the MPO's regional transit vision. As described in Chapter 1, managed lanes when properly applied can have significant benefits for transit riders.

Both the Metropolitan Transit Authority (MTA) and Regional Transportation Authority (RTA) operate express routes that use the area's freeways during the morning and afternoon peak traffic hours.

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[26] Source: Parsons Brinckerhoff.

With the launch of express bus service between Dickson and Nashville, RTA now operates regional transit service along every major corridor. Its Music City Star commuter train runs parallel to the heavily congested I-40 East corridor during the AM and PM peak periods. On I-24, I-65, and I-40 West, the "Relax 'n Ride" express bus service links downtown Nashville with surrounding communities.

MTA also operates a number of peak hour express routes that rely on portions of freeway within Davidson County. These routes offer connections between downtown Nashville and other key points around the region, including major park and ride facilities in Goodlettsville, Whites Creek, Hickory Hollow and Bellevue.

Table 7 — Current AM/PM Peak Express Service [27]

Corridor	RTA Routes	MTA Routes
I-24 East	84X (Murfreesboro–Nashville) 86X (Smyrna/LaVergne–Nashville)	33X (Hickory Hollow/Lenox Express) 37X (Tusculum/McMurray Express)
I-65 North, Ellington Pkwy	87X (Gallatin–Nashville) 92X (Hendersonville–Nashville)	35X (Rivergate Express)
I-65 South	91X (Franklin–Nashville) 95X (Spring Hill–Nashville)	
I-24 West	94X (Clarksville–Nashville) 89X (Springfield–Nashville) (Joelton Segment)	43 (Hickory Hills)
I-40 East	Music City Star (Lebanon–Nashville)	27 (Old Hickory)
I-40 West	Planned Service (Dickson–Nashville)	24X (Bellevue Express)

Where HOV lanes are currently available on I-24 and I-65, RTA and MTA riders should benefit from opportunities for their vehicles to experience reduced delays in comparison to general purpose lanes. This assumes, of course, that the HOV lane is not crowded with ineligible SOV drivers, which is likely a concern based on current violation rates. RTA's Murfreesboro Express bus service (84X), which operates on I-24 during peak periods, has had multiple schedule adjustments due to recurring congestion and an overall increase in the time required to travel between the route's major endpoints.

Table 8 and Table 9 show typical MTA and RTA transit travel times during peak periods, based on posted schedules for each route.

[27] Source: RTA published route schedules as of Sept. 2014.

Table 8 — Average Trip Times on Selected MTA Peak Express Routes [28]

MTA Routes	Corridor	Sample Trip Segment To/From Downtown Nashville
33X (Hickory Hollow/Lenox Express) 37X (Tusculum/McMurray Express)	I-24 East	**I-24/Haywood Lane** AM and PM peak: 27 minutes **Hickory Hollow P&R (I-24/Bell Rd.)** AM peak: 42 minutes PM peak: 32 minutes
35X (Rivergate Express)	I-65 North, Ellington Pkwy	**Long Hollow Pike P&R (Goodlettsville)** AM peak: 34 minutes PM peak: 38 minutes
43 (Hickory Hills)	I-24 West	**Whites Creek High School (I-24/Old Hickory Blvd.)** AM and PM peak: 30 minutes
27 (Old Hickory)	I-40 East	**I-40/Old Hickory Blvd.** AM and PM peak: 25 minutes
24X (Bellevue Express)	I-40 West	**Bellevue P&R (I-40/Newsom Station Rd.)** AM peak: 31 minutes PM peak: 28 minutes

[28] Source: MTA published route schedules as of Sept. 2014.

Table 9 — Average Trip Times on Selected RTA Peak Express Routes [29]

RTA Routes	Corridor	Sample Trip Segment To/From Downtown Nashville
84X, Murfreesboro–Nashville	I-24 East	**I-24/Medical Center Pkwy.** AM peak: 56 minutes PM peak: 53 minutes
87X, Gallatin–Nashville	I-65 North, Ellington Pkwy	**SR-386 at SR-109** AM peak: 37 minutes PM peak: 39 minutes
92X, Hendersonville–Nashville		**SR-386 at New Shackle Island Rd.** AM peak: 28 minutes PM peak: 33 minutes
91X, Franklin–Nashville	I-65 South	**I-65/Hwy. 96** AM peak: 43 minutes PM peak: 51 minutes
94X, Clarksville–Nashville	I-24 West	**I-24/Rossview Rd.** AM peak: 53 minutes PM peak: 59 minutes
89X (Springfield–Nashville) (Joelton Segment)		**I-24/Whites Creek Pk** AM peak: 24 minutes PM peak: 31 minutes
Music City Star (Lebanon–Nashville)	Parallels I-40 East	**Lebanon** AM and PM peak: 50 minutes

Lane management has significant benefits for transit. Using lane management it is possible to provide "Virtual Busways", a term coined by Bob Poole of the Reason Foundation. By managing lane demand at a level where free flow conditions are maintained, transit vehicles are able to enjoy the full benefit of an exclusive busway at a fraction of the cost relating to transit of an exclusive busway. Further, depending on project financing requirements, it is possible that a portion of the revenue stream from a priced managed facility can be used to improve and/or underwrite transit costs. I-95 in Southeast Florida, and I-15 in San Diego, California are two examples of transit benefiting both operationally and financially from managed facilities.

[29] Estimated from MTA and RTA published route schedules as of Sept. 2014.

Constructability of New Facilities

The ultimate cost and feasibility of implementing managed lanes projects on existing freeway facilities in the Nashville metropolitan area depends heavily on *constructability*, or the ease and efficiency of the construction of the project. This section includes a review of general conditions of freeway corridors in the Nashville region as they relate to possible managed lanes projects and a discussion of the suitability of future projects to existing conditions.

Corridors

The following general factors affect the constructability of different types of managed lanes facilities on a given corridor.

- **Right-of-way (ROW) width.** Where future managed lanes facilities would require construction outside the limits of the existing facility, adequate existing ROW consistent throughout the corridor minimizes the need for acquisition.
- **Developed shoulder width and need.** Some managed lane types, such as hard shoulder running (HSR), may utilize the existing shoulders of the facility, while others may require widening of the facility. Shoulders that can accommodate traffic without widening, or require only a thicker wearing surface without changes to the subgrade, allow for faster and less expensive conversion.
- **Interchange frequency and design.** The presence, type, and design of interchanges may affect decisions on the type and location of a managed lanes facility, not only through limitations but also opportunities for convenient connectivity to other facilities within the interchange itself.
- **Median width and type.** The presence of sufficiently wide medians on existing facilities may offer the opportunity to construct future managed lanes facilities within the median itself. However, characteristics such as drainage, median barriers, structures, and terrain (where the existing facility utilizes independent roadways) affect the feasibility and cost of this approach.
- **Structure type and frequency.** Impacts to existing structures (such as bridges, overpasses, stormwater drainage infrastructure, roadside barriers, or structural sign supports) on a facility may add significant time and cost to the construction of future managed lanes projects. Accounting for the constraints of these structures when selecting the types of managed lanes to implement and designing the facility may reduce the need for modifications to or replacements of the structures.

The corridor descriptions below reflect existing conditions of freeway facilities in the Nashville area in the context of these factors.

The "Inner Loop"

Interstate 65 (Northwestern Quadrant)

ROW on Interstate 65 in the northwestern quadrant of the Inner Loop varies between 300 and 400 feet. The ROW frequently features large roadside slopes.

This segment of Interstate 65 features one service interchange, a diamond interchange connecting to State Route 12 (US Route 41 Alternate, Rosa L. Parks Boulevard).

Inside shoulder widths along Interstate 65 in the northwest quadrant of the Inner Loop vary between 4 and 7 feet, while outside shoulder widths vary between 10 and 12 feet. The entire segment features concrete median barrier.

Potential options for further study along Interstate 65 in the northwestern quadrant of the Inner Loop include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Transit-only / toll (TOT) lanes;
- Express lanes; and
- Ramp metering.

Interstates 40/65 (Southwestern Quadrant)

ROW on Interstates 40/65 in the southwestern quadrant of the Inner Loop is 400 feet in width. As a depressed highway, many areas feature significant rock cuts close to the roadway.

The southwestern quadrant of the Inner Loop features three service interchanges, all of which are tight diamonds linked by collector/distributor (C/D) roadways on both sides of the Interstates.

Inside shoulder widths along Interstates 40/65 in the southwestern quadrant of the Inner Loop vary between 7 and 10 feet, while outside shoulder widths vary between 10 and 12 feet. The entire segment features concrete median barrier.

Potential options for further study along Interstates 40/65 in the southwestern quadrant of the Inner Loop include:

- Lane restrictions; and
- Bus on Shoulder System (BOSS).

Interstate 40 (Southeastern Quadrant)

ROW on Interstate 40 in the southeastern quadrant of the Inner Loop is 300 feet in width. The ROW frequently features large roadside slopes.

The southeastern quadrant of the Inner Loop features one service interchange, a diamond interchange connecting to 2nd Avenue South and 4th Avenue South. Of note is the short distance between this interchange and the adjacent system interchanges with Interstate 24 and Interstate 65; the ramps for each interchange are only approximately 800 feet apart, with the on-ramp from 2nd Avenue South merging with Interstate 40 beyond the diverge point for the Interstate 24 off-ramp. Additionally, the off-ramps for Interstate 24 and Interstate 65 are left-exit, introducing additional weaving conflicts. Regulatory signs posted at the 2nd Avenue South / 4th Avenue South interchange prohibit exiting to Interstate 24 and Interstate 65 for users entering the roadway via the interchange.

Inside shoulder widths along Interstate 40 in the southeastern quadrant of the Inner Loop vary between 7 and 10 feet, while outside shoulder widths vary between 10 and 12 feet. The entire segment features concrete median barrier.

Potential options for further study along Interstate 40 in the southeastern quadrant of the Inner Loop include:

- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);and
- Ramp metering.

Interstate 24 (Northeastern Quadrant)

ROW on Interstate 24 in the northeastern quadrant of the Inner Loop varies between 300 and 400 feet. The ROW frequently features large roadside slopes.

The northeastern quadrant of the Inner Loop features three service interchanges, of which two are partial cloverleaf interchanges and one is a full cloverleaf interchange. The interchanges also utilize collector/distributor (C/D) roads as well as auxiliary lanes that introduce weaving conflicts.

Inside shoulder widths along Interstate 24 in the northeastern quadrant of the Inner Loop vary between 7 and 10 feet, while outside shoulder widths vary between 10 and 12 feet. The entire segment features concrete median barrier, except for a segment approximately 3,000 feet in length north of the Spring Street interchange.

Potential options for further study along Interstate 24 in the northeastern quadrant of the Inner Loop include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS); and
- Express lanes.

Interstate 24

West of Nashville

ROW on Interstate 24 west of Nashville varies between 300 and 900 feet. The ROW frequently features large roadside slopes, with rock cuts throughout.

Interstate 24 features two system interchanges and five service interchanges between downtown Nashville and the northwestern edge of the MPO area. Of the system interchanges, the Interstate 65 interchange is a three-way directional interchange and the State Route 155 (Briley Parkway) interchange is a full cloverleaf interchange. The service interchanges feature a mixture of diamond, partial cloverleaf, and hybrid interchanges.

Inside shoulder widths along Interstate 24 east of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths generally vary between 10 and 12 feet. Median widths along Interstate 24 west of Nashville vary from 30 to 90 feet. In areas where the corridor has independent roadways the median features wooded, sloping terrain.

Potential options for further study along Interstate 24 west of Nashville include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Transit-only / toll (TOT) lanes;
- Express lanes;
- Reversible lanes; and
- Exclusive-use ramps.

East of Nashville

ROW on Interstate 24 west of Nashville varies between 300 and 800 feet. The ROW alternates between slight fills and cuts depending on the local topography, with several rock cuts throughout.

Interstate 24 features four system interchanges between downtown Nashville and the southeastern edge of the MPO area; of these, three are directional interchanges, while one (at State Route 840) is a hybrid directional / cloverleaf interchange. The corridor also features 16 service interchanges that consist of a mixture of diamond, partial cloverleaf, and hybrid interchanges.

Inside shoulder widths along Interstate 24 east of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths generally vary between 10 and 12 feet.

Concrete median barrier extends along Interstate 24 east of Nashville approximately 15.5 miles from the Interstate 40 interchange and from State Route 840 to State Route 10 (US Route 231) in Murfreesboro. Median widths elsewhere vary between 30 and 120 feet; notably, a four-mile segment from Rock Springs Road to Baker Road features a 120-foot median.

Potential options for further study along Interstate 24 east of Nashville include:

- HOV-to-HOT conversions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS); and
- Ramp metering.

Interstate 40

West of Nashville

ROW on Interstate 40 west of Nashville is typically 300 feet in rural areas, with segments near interchanges as wide as 900 feet. In urban areas in Davidson County, the ROW narrows to as little as 180 feet, notably near the interchanges with State Route 1 (US Route 70S), Interstate 440, and Jefferson Street. The ROW alternates between slight fills and cuts depending on the local topography, with several rock cuts throughout.

Interstate 40 features four system interchanges and nine service interchanges between downtown Nashville and the western boundary of the MPO area. Of the system interchanges, three are directional, while one (at State Route 840) is a three-way trumpet interchange. The service interchanges feature a mixture of diamond and partial cloverleaf interchanges.

Inside shoulder widths along Interstate 40 west of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths generally vary between 10 and 12 feet. Concrete median barrier extends along Interstate 40 west of Nashville approximately 12.5 miles from the Interstate 65 interchange to State Route 1 (US Route 70S). Median widths to the west vary from 30 to 375 feet; in areas where the corridor has independent roadways the median features wooded, sloping terrain.

Potential options for further study along Interstate 40 west of Nashville include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- HOV-to-HOT conversions;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Transit-only / toll (TOT) lanes; and
- Ramp metering.

East of Nashville

ROW on Interstate 40 east of Nashville is typically 300 feet. The ROW alternates between slight fills and cuts depending on the local topography, with several rock cuts throughout.

Interstate 40 features four system interchanges between downtown Nashville and the eastern boundary of the MPO area. The corridor also features 13 service interchanges, of which all are diamond, partial cloverleaf, or hybrid interchanges. Three feature only partial access to connecting roadways.

Inside shoulder widths along Interstate 40 east of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths generally vary between 10 and 12 feet. Notably, the segment concurrent with Interstate 24 southeast of downtown Nashville features narrower inside and outside shoulders, with a minimum width of 2 feet; bridges and overpasses along this segment lend additional constraints to the shoulder width.

Concrete median barrier extends along Interstate 40 east of Nashville approximately 20 miles from the Interstate 24 interchange to State Route 109. Median widths to the east vary from 40 to 52 feet.

Potential options for further study along Interstate 40 east of Nashville include:

- HOV-to-HOT conversions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS); and
- Ramp metering.

Interstate 65

South of Nashville

ROW on Interstate 65 south of Nashville varies between 300 and 400 feet. The ROW alternates between slight fills and cuts depending on the local topography, with several rock cuts throughout.

Interstate 65 features four system interchanges and twelve service interchanges between downtown Nashville and the southern boundary of the MPO area. Of the system interchanges, two are hybrid directional / partial cloverleaf interchanges, while the interchange with Interstate 40 in downtown Nashville is a three-way directional interchange and the interchange with Interstate 440 is a stack interchange. The service interchanges vary between diamond and partial cloverleaf interchanges, with one single-point urban interchange (SPUI) at McEwen Drive in Franklin.

Inside shoulder widths along Interstate 65 south of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths generally vary between 10 and 12 feet. The overpass at Hamilton Avenue south of downtown Nashville restricts shoulder widths due to the structural design of the bridge.

Concrete median barrier extends along Interstate 65 south of Nashville approximately 23 miles from the Interstate 40 interchange to State Route 840, and another 0.75 miles between State Route 840 and State Route 396 (Saturn Parkway), with the exception of an approximately 0.67-mile segment north of State Route 254 (Old Hickory Boulevard) featuring a 100-foot median and independent roadways. Median widths outside of these areas vary from 38 to 52 feet.

Potential options for further study along Interstate 65 south of Nashville include:

- HOV-to-HOT conversions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Ramp metering; and
- Exclusive-use ramps.

North of Nashville

ROW on Interstate 65 north of Nashville varies between 300 and 600 feet. The ROW frequently features large roadside slopes, with rock cuts throughout, particularly on the grade north of Millersville at the Davidson/Robertson County line. Sound barriers are also prevalent along segments from Nashville to Goodlettsville.

Interstate 65 features four system interchanges and nine service interchanges between downtown Nashville and the northern boundary of the MPO area. The system interchanges are largely directional, with some cloverleaf ramps, while the service interchanges are diamond or hybrid partial cloverleaf interchanges. The system interchange at State Route 386 (Vietnam Veterans Parkway) additionally only offers partial access.

Inside shoulder widths along Interstate 65 north of Nashville vary between 4 and 12 feet, with the larger widths occurring in sections with concrete median barriers; outside shoulder widths vary between 10 and 12 feet. The Fern Avenue overpass immediately north of the Interstate 65 / Interstate 24 interchange in downtown Nashville reduces these shoulder widths to 3 feet, with the bridge abutments constraining the width of the roadways.

Concrete median barrier extends along Interstate 65 north of Nashville approximately 9.5 miles north from the Interstate 24 interchange to State Route 386 (Vietnam Veterans Parkway). Median widths to the north vary from 52 to 300 feet; in areas where the corridor has independent roadways the median features wooded, sloping terrain, notably on the grade south of State Route 257 (Bethel Road).

Potential options for further study along Interstate 65 north of Nashville include:

- HOV-to-HOT conversions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Express lanes;
- Reversible lanes; and
- Ramp metering.

Interstate 440

ROW on Interstate 440 is typically 300 feet, widening to 600 feet near the interchanges with Interstate 24 and Interstate 40. As a depressed highway, many areas feature significant rock cuts and sound barriers close to the roadway.

Interstate 440 features four system and four service interchanges; the system interchanges are mostly three-way directional interchanges, with one stack interchange, while the service interchanges are partial cloverleaf interchanges.

Median widths along Interstate 440 vary from 16 to 60 feet. Inside shoulder widths vary between 4 and 12 feet; for most of the route the inside shoulder incorporates swales for stormwater drainage, reducing the ability of the shoulder to support traffic. Outside shoulders vary between 10 and 12 feet.

Potential options for further study along Interstate 440 include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes; and
- Exclusive-use ramps.

State Route 6 (US Route 31E, Ellington Parkway)

ROW on State Route 6 (US Route 31E, Ellington Parkway) varies between 150 and 250 feet. The ROW features several steep fills and cuts, as well as rock cuts.

State Route 6 (US Route 31E, Ellington Parkway) features two system interchanges, connecting to State Route 11 (US Routes 31W/41/431, Spring Street) at its south end and Interstate 65, State Route 155 (Briley Parkway), and Briarville Road at its north end. Both system interchanges are hybrid directional / partial cloverleaf interchanges. The roadway also features five service interchanges, of which two are diamond interchanges and three are partial cloverleaf interchanges.

Inside shoulder widths on State Route 6 (US Route 31E, Ellington Parkway) vary between 2 and 4 feet, with outside shoulders varying between 10 and 12 feet. Median widths are typically 32 feet.

Potential options for further study along State Route 6 (US Route 31E, Ellington Parkway) include:

- Bus on Shoulder System (BOSS);
- Express lanes;
- Reversible lanes; and
- Exclusive-use ramps.

State Route 155 (Briley Parkway)

ROW on State Route 155 (Briley Parkway) varies between 100 and 350 feet. The ROW features sizable cuts and fills in some areas, with several large rock cuts close to the roadway.

State Route 155 (Briley Parkway) features 5 system interchanges and 13 service interchanges. The system interchanges vary greatly in design and complexity; of note are the full cloverleaf interchange at Interstate 24 [requiring weaving movements on State Route 155 (Briley Parkway)] and the combined interchanges at Interstate 65 and State Route 6 (US Route 31E, Ellington Parkway), the ramps of which are separated by only approximately 1,000 feet. The designs of the service interchanges also vary greatly, including one single-point urban interchange (SPUI) at McGavock Pike.

Most of State Route 155 (Briley Parkway) features concrete median barrier, with an approximately 1.4-mile segment from Centennial Boulevard to Interstate 40 featuring a 20-foot grassed, depressed median. Inside shoulder widths vary between 2 and 8 feet, while outside shoulder widths vary between 6 and 12 feet.

Potential options for further study along State Route 155 (Briley Parkway) include:

- High-occupancy vehicle (HOV) lanes.

State Route 386 (Vietnam Veterans Parkway)

ROW on State Route 386 (Vietnam Veterans Parkway) varies between 300 and 600 feet. The ROW features sizable cuts and fills in some areas, with some rock cuts close to the roadway as well.

Interchange types and designs vary greatly along State Route 386 (Vietnam Veterans Parkway), with three system interchanges and seven service interchanges; several feature only varying degrees of partial access to connecting roadways.

Concrete median barrier extends along State Route 386 (Vietnam Veterans Parkway) approximately 4 miles east from the Interstate 65 interchange to the Forest Retreat Road overpass, with another approximately 1.3-mile segment featuring concrete median barrier at the State Route 6 (US Route 31E, Johnny Cash Parkway) interchange. Median widths elsewhere are typically 40 feet.

Inside shoulder widths on State Route 386 (Vietnam Veterans Parkway) vary between 4 and 7 feet, with outside shoulders between 10 and 12 feet.

Ramp metering could be employed as a short term interim strategy, or as a long term strategy. As a short term strategy, in congested conditions any metering strategy that reduces vehicle density (vehicles per mile) on the facility will likely have a positive effect. This effect will, however, diminish as demand grows.

As a long term strategy, it is possible to employ ramp metering to maintain the optimum density on the facility. Under low density environments, as in off peak times, the greater the number of vehicles on the road, the greater the throughput. However, once a critical density is reached, the interference between vehicles overcomes the benefit of additional cars, actually reducing throughput. Ramp metering can alleviate this; however, the storage of vehicles waiting to get on the facility can degrade connecting arterial performance. If ramp metering is contemplated, rigorous study of the facility should be undertaken so that all issues may be addressed.

Potential options for further study along State Route 386 (Vietnam Veterans Parkway) include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes; and
- Ramp metering.

State Route 396 (Saturn Parkway)

ROW on State Route 396 (Saturn Parkway) is typically 300 feet, widening to 850 feet at the interchange with Interstate 65. The ROW alternates between slight fills and cuts depending on the local topography, with few rock cuts. Median widths throughout are 54 feet, with outside shoulders between 10 and 11 feet and inside shoulders between 4 and 5 feet.

State Route 396 (Saturn Parkway) features two system interchanges, a trumpet interchange at Interstate 65 and a hybrid directional / partial cloverleaf interchange at State Route 6 (US Route 31, Columbia Pike) that also serves the entrance to General Motors (GM) Spring Hill Manufacturing. The route also features two diamond service interchanges at Kedron Road and Port Royal Road. None of the interchanges are constrained by development and all feature adequate ROW.

Potential options for further study along State Route 396 (Saturn Parkway) include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS);
- Express lanes;
- Reversible lanes; and

- Exclusive-use ramps.

State Route 840

ROW on State Route 840 varies between 150 and 800 feet. The ROW features sizable cuts and fills in some areas, with several large rock cuts close to the roadway.

State Route 840 features 5 system interchanges and 16 service interchanges. The system interchanges vary greatly in design and complexity, featuring a mixture of directional, semi-directional, and cloverleaf ramps. The service interchanges mostly consist of diamond and partial cloverleaf interchanges, with one single-point urban interchange (SPUI) at State Route 452 (Bill France Boulevard).

Median widths along State Route 840 are generally 60 feet throughout the length of the corridor, with 4-foot inside shoulders and 10-foot outside shoulders.

Potential options for further study along State Route 840 include:

- High-occupancy vehicle (HOV) lanes;
- High-occupancy vehicle / toll (HOT) lanes;
- Lane restrictions;
- Hard shoulder running (HSR);
- Bus on Shoulder System (BOSS); and
- Transit-only / toll (TOT) lanes.

Future Improvement Plans

The Nashville Area MPO lists several projects incorporating or potentially incorporating managed lanes in its 2035 Regional Transportation Plan (RTP). Taking into consideration the overall characteristics of each freeway corridor in the MPO area, the relative constructability of these projects may be inferred.

High-Occupancy Vehicle (HOV) Lanes

Several widening projects listed in the 2035 RTP include the construction of HOV lanes. Some of these projects are under construction or have been completed, while others are in various stages of planning. The projects in the latter group include:

- Interstate 65: Widen from 6 to 8 lanes between State Route 255 (Harding Place) and Interstate 40, including the addition of 2 HOV lanes (1012-205, FY 2011–2015);
- Interstate 40: Widen from 6 to 8 lanes between State Route 1 (US Route 70S) and Interstate 440, including the addition of 2 HOV lanes (1012-207, FY 2016–2025);
- Interstate 40: Widen from 6 to 8 lanes between Interstate 440 and Interstate 65, including the addition of 2 HOV lanes (1012-208, FY 2016–2025);
- Interstate 65: Widen from 4 to 8 lanes from Rivergate Parkway to State Route 41 (US Route 31W), including the addition of 2 HOV lanes (1052-212, FY 2016–2025);
- Interstate 40: Widen from 4 to 6 lanes from State Route 840 to State Route 26 (US Route 70), including the addition of 2 HOV lanes (1072-213, FY 2016–2025); and

- Interstates 40/65 in downtown Nashville: Widen from 6 to 8 lanes, including the addition of 2 HOV lanes (1012-154, FY 2026–2035).

In addition, there are two roadway widening projects listed in the 2035 RTP which do not explicitly mention managed lanes but could potentially include them:

- SR 6 (US 31E, Ellington Parkway): Widen from 4 to 6 lanes from North First Street to Broadmoor Drive (1012-218, FY 2016—2025); and
- SR 386 (Vietnam Veterans Parkway): Widen from 4 to 6 lanes from Saundersville Road to the I-65 North interchange (1052-179, FY 2026—2035).

Interstate 65 from State Route 255 (Harding Place) to Interstate 40

Project number 1012-205 in the 2035 RTP, proposed for completion in the 2016 to 2025 timeframe, would modify Interstate 65 to provide eight travel lanes for its full length from State Route 255 (Harding Place) to Interstate 40 in south Nashville. This project, approximately 4.7 miles in length, would include two HOV lanes.

Interstate 65 currently features eight travel lanes from State Route 255 (Harding Place) to Interstate 440, a distance of approximately 2.4 miles, and six travel lanes from Interstate 440 to Interstate 40, a distance of approximately 2.3 miles. The route also features auxiliary lanes between interchanges that might be converted to travel lanes as part of the project. Existing HOV lanes end at State Route 255 (Harding Place), offering an opportunity to maintain them throughout the project. Concrete median barriers are present throughout the segments containing the proposed project.

Assuming the roadway is widened to the outside, and the proposed HOV lanes occupy the leftmost lane in each direction, their constructability is very high, requiring only marking and signing changes to the existing roadway. The constructability of the widened lanes does not affect the constructability of the HOV lanes.

Interstate 40 from State Route 1 (US Route 70S) to Interstate 440

Project number 1012-207 in the 2035 RTP, proposed for completion in the 2016 to 2025 period, would widen Interstate 40 to eight travel lanes from State Route 1 (US Route 70S) to Interstate 440 in west Nashville. This project, approximately 9.7 miles in length, would include two HOV lanes.

Interstate 40 currently features six travel lanes across the entire length of the proposed project, except for the approximately 2.8-mile segment from State Route 155 (Briley Parkway) to Interstate 440, which features three travel lanes in the westbound direction and four travel lanes in the eastbound direction. Concrete median barrier is present throughout the segments containing the proposed project.

Because the proposed HOV lanes would occupy existing general-purpose lanes, their constructability is very high, requiring only marking and signing changes to the existing roadway. Assuming the roadway is widened to the outside, the constructability of the widened lanes does not affect the constructability of the HOV lanes.

Interstate 40 from Interstate 440 to Interstate 65

Project number 1012-208 in the 2035 RTP, proposed for completion in the 2016 to 2025 timeframe, would widen Interstate 40 to eight travel lanes from Interstate 440 to Interstate 65 in west Nashville. This project, approximately 1.8 miles in length, would include two HOV lanes.

Interstate 40 currently features six travel lanes and concrete median barrier across the entire length of the proposed project. Assuming the roadway is widened to the outside, and the proposed HOV lanes occupy the leftmost lane in each direction, their constructability is very high, requiring only marking and signing changes to the existing roadway. The constructability of the widened lanes does not affect the constructability of the HOV lanes.

Interstate 65 from Rivergate Parkway to State Route 41 (US Route 31W)

Project number 1052-212 in the 2035 RTP, proposed for completion in the 2016 to 2025 period, would widen Interstate 65 to eight travel lanes from Rivergate Parkway to State Route 41 (US Route 31W) through Goodlettsville in Davidson and Sumner Counties. This project, approximately 3.5 miles in length, would include two HOV lanes.

Interstate 65 currently features six travel lanes from Rivergate Parkway to State Route 174 (Long Hollow Pike), a distance of approximately 1.0 miles, and four travel lanes from State Route 174 (Long Hollow Pike) to State Route 41 (US Route 31W), a distance of approximately 1.7 miles. The project might also include widening from State Route 386 (Vietnam Veterans Parkway) to Rivergate Parkway, a distance of approximately 0.8 miles, to connect to existing eight-lane segments as well as existing HOV lanes.

Concrete median barrier currently exists on Interstate 65 to approximately 0.4 miles north of Rivergate Parkway; following a transition, median widths are 28 feet in the six-lane segments and 50 feet in the four-lane segments. The grassed, depressed median in these segments contains no trees, light standards, or other obstacles, though it includes two road crossings and one stream crossing.

Assuming that the additional lanes are constructed in the median and the HOV lanes occupy the newly-constructed leftmost lane in both directions upon completion, the proposed project is relatively very constructible.

Interstate 40 from State Route 840 to State Route 26 (US Route 70)

Project number 1072-213 in the 2035 RTP, proposed for completion in the 2016 to 2025 timeframe, would widen Interstate 40 to six travel lanes, adding two HOV lanes, from State Route 840 to State Route 26 (US Route 70) in Wilson County, a distance of approximately 6.5 miles.

Interstate 40 currently features four travel lanes from State Route 840 to State Route 26 (US Route 70), with a grassed, depressed median 60 feet in width. The project might also include widening from State Route 109 to State Route 840, a distance of approximately 1.8 miles, to connect to existing eight-lane segments as well as existing HOV lanes.

Assuming that the additional lanes are constructed in the median and the HOV lanes occupy the newly-constructed leftmost lane in both directions upon completion, the proposed project is relatively very constructible.

Interstates 40/65 (Inner Loop Southwestern Quadrant)

Project number 1072-213 in the 2035 RTP, proposed for completion in the 2026 to 2035 timeframe, would widen Interstates 40/65 to eight lanes where the interstates run concurrently (on the southwest quadrant of the “Inner Loop”). This project, approximately 2.3 miles in length, would include two HOV lanes.

Interstates 40/65 currently feature six travel lanes and concrete median barrier for the entire length of the proposed project. The route also features auxiliary lanes between interchanges that might be converted to travel lanes as part of the project.

While the HOV lanes along the project are very constructible, assuming they occupy the existing leftmost travel lane in each direction, a key factor in their constructability at the project termini is the need to connect them to proposed HOV lanes on Interstate 40 and Interstate 65 adjacent to the concurrency. The interchange on the northwest end of the concurrency is a three-way semi-directional interchange, while the interchange to the southeast is a three-way directional interchange. In both cases, none of the ramps within the interchange facilitate direct connections between HOV lanes; drivers utilizing these lanes on one facility would have to cross several lanes to reach the HOV lanes following the interchange. Direct connections for HOV lanes may be accomplished by reconstructing both interchanges or adding separate ramps for HOV lanes; in the latter case, the ability to also provide connections to the rest of the Inner Loop is preserved.

State Route 6 (US Route 31E, Ellington Parkway) from North First Street to Broadmoor Avenue

Project number 2012-218 in the 2035 RTP, proposed for completion in the 2016 to 2025 period, would widen State Route 6 (US Route 31E, Ellington Parkway) to provide six travel lanes along its entire length from North First Street to Broadmoor Avenue in east Nashville, a distance of approximately 4.6 miles. Preliminary engineering and ROW acquisition for this project has been completed.

State Route 6 (US Route 31E, Ellington Parkway) currently features four travel lanes from North First Street to Broadmoor Avenue, with a median width of approximately 32 feet. Five service interchanges currently exist in the area of the proposed project, which might require modification to accommodate the additional lanes. The roadway segment also features five overpasses and four underpasses; of the latter, all feature bridge piers in the median.

Assuming the roadway is widened to the inside, the proposed project is relatively constructable. Although this project does not describe the additional lanes as managed, the *Northeast Corridor Mobility Study*, published by the Nashville MPO in August 2011, suggests a bus rapid transit (BRT) option for movement between Nashville and Gallatin that would utilize transit-only lanes on State Route 6 (US Route 31E, Ellington Parkway) within the area of the proposed project. The proposed lanes might be converted to managed lanes for this option or otherwise while maintaining the existing general-purpose lanes (though constructing a segregated facility would require reconstruction of the four overpassing bridges along the route). However, this conversion is contingent on the ability of the existing lanes to serve projected general-purpose traffic.

State Route 386 (Vietnam Veterans Parkway) from Interstate 65 to Saundersville Road

Project number 1052-179, proposed for completion in the 2026 to 2035 period, would widen State Route 386 (Vietnam Veterans Parkway) to provide six travel lanes from its existing terminus at Interstate 65 in Davidson County to Saundersville Road in Hendersonville, Sumner County, a distance of approximately 8.8 miles.

State Route 386 (Vietnam Veterans Parkway) currently features four travel lanes from Interstate 65 to Saundersville Road, Concrete median barrier extends along the roadway approximately 4 miles east from the Interstate 65 interchange to the Forest Retreat Road overpass, with the remainder within the proposed project area featuring a grassed, depressed median approximately 40 feet in width. The roadway segment also features eight overpasses and five underpasses.

Assuming the roadway is widened to the outside where concrete median barrier is present and widened to the inside elsewhere, the project is relatively constructible. Although this project does not describe the additional lanes as managed, the Northeast Corridor Mobility Study, published by the Nashville MPO in August 2011, suggests a bus rapid transit (BRT) option for movement between Nashville and Gallatin that would utilize transit-only lanes on State Route 386 (Vietnam Veterans Parkway) within the area of the proposed project. Additionally, the project allows for the addition of two managed lanes while maintaining the existing number of general-purpose lanes (though constructing a segregated facility would require reconstruction of the concrete median barrier and several overpasses along the route). However, this conversion is contingent on the ability of the existing lanes to serve projected general-purpose traffic.

High-Occupancy Vehicle (HOV) Ramps

In addition to projects adding HOV lanes as part of widening projects, the 2035 RTP also lists projects that propose to add dedicated HOV ramps from the Inner Loop to surface streets in downtown Nashville. The projects include:

- Interstates 40/65 at 11th Avenue North and 12th Avenue North (1014-206, FY 2016–2025);
- Interstates 40/65 at 12th Avenue and Charlotte Avenue (1014-209, FY 2016–2025);
- Interstate 24 at Shelby Avenue (1014-210, FY 2016–2025); and
- Interstate 65 at North 1st Street (1014-211, FY 2016–2025).

Interstates 40/65 at 11th Avenue North and 12th Avenue North

Project number 1014-206 in the 2035 RTP, proposed for completion by 2025, would add dedicated HOV ramps from Interstates 40/65 to 11th Avenue North and 12th Avenue North on the southwest quadrant of the Inner Loop. The project would include improvements on Jo Johnston Avenue for approximately 0.3 miles from Interstates 40/65 to 10th Circle North, and improvements on 10th Circle North for approximately 0.1 miles from Jo Johnston Avenue to State Route 12 (US Route 41 Alternate, Rosa L. Parks Boulevard).

At the proposed location, Interstates 40/65 feature six travel lanes and two auxiliary lanes, separated by concrete median barrier. The interstates overpass Jo Johnston Avenue, which features two ten-foot-wide travel lanes and two six-foot-wide bicycle lanes between Interstates 40/65 and 10th Circle North. In turn, 10th Circle North features two twelve-foot-lanes and surface parking along its north side between Jo Johnston Avenue and State Route 12 (US Route 41 Alternate, Rosa L. Parks Boulevard).

The primary obstacle to constructing this project is the configuration of the interstates at the Jo Johnston Avenue overpass. Assuming HOV lanes remain to the inside of the general-purpose lanes in this segment (as they are throughout the Nashville metropolitan area), connecting the two roadways via dedicated HOV ramps would require significant reconstruction of the interstates or construction of a flyover structure for the ramps. The proposed Capitol View development, as well as two CSX Transportation railway overpasses, may also hinder the construction of improvements to Jo Johnston Avenue as well as its capacity to carry significant volumes of traffic.

Interstates 40/65 at 12th Avenue North and Charlotte Avenue

Project number 1014-209 in the 2035 RTP, proposed for completion by 2025, would add dedicated HOV ramps from Interstates 40/65 to 12th Avenue North and Charlotte Avenue on the southwest quadrant of the Inner Loop.

At the proposed location, Interstates 40/65 feature six travel lanes and two auxiliary lanes, separated by concrete median barrier. The interstates overpass Charlotte Avenue, which features four travel lanes and two auxiliary lanes. The interchange features two diamond ramps with connector/distributor (C/D) roads linking the interstates to surface streets in all four quadrants.

The primary obstacle to constructing this project is the configuration of the interstates at the Charlotte Avenue interchange. Assuming HOV lanes remain to the inside of the general-purpose lanes in this segment (as they are throughout the Nashville metropolitan area), connecting the two roadways via dedicated HOV ramps would require significant reconstruction of the interstates or construction of a flyover structure for the ramps.

Interstate 24 at Shelby Avenue

Project number 1014-210 in the 2035 RTP, proposed for completion by 2025, would add dedicated HOV ramps from Interstate 24 to Shelby Avenue on the northeastern quadrant of the Inner Loop.

At the proposed location, Interstate 24 features six travel lanes and two auxiliary lanes. Shelby Avenue overpasses the interstate, featuring six travel lanes, two auxiliary lanes, and two bicycle lanes. The interchange features three diamond ramps and two cloverleaf ramps, with three collector/distributor (C/D) roads.

Because Shelby Avenue overpasses Interstate 24, HOV ramps could be constructed directly from the HOV lanes to the overpass, precluding the need for more complicated structures or reconstruction. However, the existing travel lanes on the interstate would require realignment to accommodate the HOV ramps.

Interstate 24 at North 1st Street

Project number 1014-211 in the 2035 RTP, proposed for completion by 2025, would add dedicated HOV ramps from Interstate 24 to North 1st Street on the northeastern quadrant of the Inner Loop.

At the proposed location, Interstate 24 features six travel lanes and two auxiliary lanes. The interstate overpasses Spring Street, which features four travel lanes and two auxiliary lanes. The interchange is a full cloverleaf, with one off-ramp connecting to North 1st Street.

The primary obstacle to constructing this project is the configuration of Interstate 24 at the Spring Street interchange. Assuming HOV lanes remain to the inside of the general-purpose lanes in this segment (as they are throughout the Nashville metropolitan area), connecting the two roadways via dedicated HOV ramps would require significant reconstruction of the interstate or construction of a flyover structure for the ramps.

Constructability Matrix

An analysis was made of various facilities in the Nashville area to provide initial insight into their potential for various lane management strategies. It should be noted that in keeping with this assessment, these are sketch level planning results, and significant additional study could change these conclusions significantly. This assessment can provide guidance into what alternatives may provide the better potential for success, but it does not provide the level of study needed to definitively advance or reject an alternative.

In Figure 27 below, potential managed lanes strategies have been organized into several broad categories of improvements and ranked in terms of their likely feasibility in each corridor. Categories include:

- **Repurposing of existing lanes:** As the name states, this involves converting an existing lane to another use. For the Nashville region, this would most likely be conversion of an HOV lane to HOT. Although it is possible to repurpose a general purpose lane for a more restricted use (such as converting a general purpose lane to HOV or HOT), public response to such changes has been exceptionally unfavorable. For that reason, conversion of existing general purpose lanes is not suggested, and was not contemplated in this category.
- **Repurposing of existing shoulders:** Repurposing existing shoulders has found public acceptability in many cities, as discussed elsewhere in this assessment. Therefore the potential of repurposing a shoulder to a mixed use shoulder lane or a bus on shoulder lane was considered. As shown in Figure 27, there are some locations in Nashville where bus-only shoulders are more feasible than mixed-use shoulders. This occurs in sections with "pinch points" where a bus could reasonably re-enter the general purpose lanes to avoid the constriction, but a mixed-use shoulder would result in too many drivers attempting to merge back into general traffic.
- **Adding laneage:** Adding lanes is exactly as described, i.e. a new lane for the indicated use would be constructed adjacent to the existing lanes.
- **Adding a segregated facility:** Adding a segregated facility is similar to adding lanes, except the new lane is not located immediately adjacent to the existing facility. As an example, the Northwest Corridor Reversible Lanes currently under construction in metropolitan Atlanta will be placed to the west of all lanes on I-75 rather than between the north and southbound lanes.
- **Improving access points:** Ramp metering does not require the addition of lanes on the mainline facility. However, the evaluations in Figure 27 reflect more feasibility for ramp metering in areas where a relatively high amount of ramp storage exists or could be provided. Providing a transit bypass could also be possible where it is feasible to widen ramps under consideration for metering.

Transit has a significant positive synergy with all of these options, and Transit Only Lanes could be considered as an alternative to HOV lanes. However, to ensure public acceptance, care must be taken that valuable roadway capacity does not go underutilized. This can be alleviated by allowing HOVs access to the lanes or by HOT conversion where the revenue is dedicated to transit purposes. Particularly in the case of HOT conversion, transit benefits lane capacity that would be unused if the lane were developed as a transit only lane. This maximizes the benefit of the lane to transit by providing free flow capacity and a source of operating revenue.

As seen in Figure 27 below, a qualitative assessment of good, fair, or poor was assigned to each alternative/corridor combination.

- A ranking of **good** was given where it appears there is a likelihood of the alternative/corridor being developed in an efficient manner at a reasonable cost for the type of improvement contemplated. Further detailed study will be needed to confirm this or identify potential issues that are not apparent at this level of assessment.
- A ranking of **fair** was given to alternatives/corridors that in general appear to be reasonable, but have a higher likelihood of facing a significant cost factor or other issues that would make development of the alternative more difficult.

- A ranking of **poor** indicates that there is a strong possibility of significant issues that would impede implementation of the alternative/corridor project. Further detailed study will be needed to confirm this or potentially find solutions that are not apparent at this level of assessment.

Figure 27 — Managed Lanes Constructability Matrix

Legend

- = Not Applicable
- = Good
- = Fair
- = Poor

		Repurpose Existing Lanes			Repurpose Existing Shoulders		Add Laneage						Add Segregated Facility		Misc. Improvements	
		HOV Lanes	HOV-to-HOT Conversion	Lane Restrictions	HSR	BOSS	HOV Lanes	HOT Lanes	TOT Lanes	Transit-Only Lanes	Express Lanes	Lane Restrictions	Express Lanes	Reversible Lanes	Ramp Metering	Exclusive-Use Ramps
"Inner Loop"	Interstate 24 (NE Quadrant)	Poor	Not Applicable	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor	Poor	Poor	Poor
	Interstate 40 (SE Quadrant)	Poor	Not Applicable	Fair	Fair	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor
	Interstates 40/65 (SW Quadrant)	Poor	Not Applicable	Fair	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
	Interstate 65 (NE Quadrant)	Poor	Not Applicable	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Poor
Radial Corridors	Interstate 24 (W of Nashville)	Not Applicable	Not Applicable	Not Applicable	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Fair	Good
	Interstate 24 (E of Nashville)	Not Applicable	Good	Not Applicable	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Good	Fair
	Interstate 40 (W of Nashville)	Not Applicable	Not Applicable	Not Applicable	Good	Good	Good	Good	Good	Good	Good	Good	Fair	Fair	Good	Fair
	Interstate 40 (E of Nashville)	Not Applicable	Good	Not Applicable	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Good	Good
	Interstate 65 (S of Nashville)	Not Applicable	Good	Not Applicable	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Good	Good
	Interstate 65 (N of Nashville)	Not Applicable	Good	Not Applicable	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Good	Fair
	State Route 6 (US Route 31E, Ellington Pkwy)	Not Applicable	Not Applicable	Not Applicable	Fair	Good	Fair	Fair	Poor	Fair	Fair	Fair	Good	Good	Fair	Good
	State Route 386 (Vietnam Veterans Pkwy)	Not Applicable	Not Applicable	Not Applicable	Fair	Fair	Fair	Fair	Poor	Fair	Fair	Fair	Fair	Fair	Good	Fair
	State Route 396 (Saturn Pkwy)	Not Applicable	Not Applicable	Not Applicable	Good	Good	Good	Good	Fair	Fair	Good	Good	Good	Good	Fair	Good
Circumferential Corridors	Interstate 440	Poor	Not Applicable	Fair	Poor	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor	Poor	Fair	Good
	State Route 155 (Briley Pkwy)	Fair	Not Applicable	Good	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
	State Route 840	Not Applicable	Not Applicable	Not Applicable	Good	Good	Good	Good	Good	Fair	Fair	Good	Fair	Fair	Fair	Fair

Policy and Legislative Considerations for Managed Lanes in the Nashville Region

Policy and Legislative Actions

Policy and legislative considerations are as significant a factor in development of any type of managed lanes as is the actual design of the lanes. Whether or not pricing should be involved in lane management, whether management of all the lanes through ramp metering should be considered, and whether efforts should focus on large vehicles or two axle vehicles will all need to be decided. Further, legislative action will likely be needed if the region wishes to pursue options that involve price management of lanes. All of these factors must be taken into account if managed lanes are to be successful in Nashville.

Public Outreach

To raise awareness of managed lanes in the Nashville area, a public outreach effort should be undertaken. This effort could include public service announcements, use of the MPO's and partner agencies' websites, and other established mechanisms for marketing and education. The focus of the public outreach would be to reinforce the fact that Tennessee does have a HOV program. It could also be used to introduce potential changes in the Tennessee HOV program to evolve it into a managed lane program that is able to enhance regional mobility. By proceeding in this manner the message can be conveyed to the public that the primary motive is to maximize the operational benefits that can be obtained from the region's transportation infrastructure.

Legislative – State

State policy actions on managed lanes are likely to focus first on improving public awareness and proper operation of the managed lanes that already exist in the Nashville and Memphis regions. At recent public events, TDOT leaders have mentioned the state's interest in working with transit providers and others to address operational issues for the HOV lanes in these areas. One of the opportunities that has been noted is the ability of transit vehicles to use the HOV lanes during peak hours. This of course assumes that the lanes are operating effectively and are not filled with single-occupant vehicles, which has been recognized as an ongoing challenge for the Middle Tennessee HOV system.

The state has also indicated some interest in exploring a wider menu of managed lane approaches, including the potential for applying Bus on Shoulder System, or BOSS. There does not appear to be a need for legislative action in order to apply this or any other non-priced managed lane tools; however, a legal review should be undertaken early in the process for this or any other specific option to determine whether and what legislative action may be needed. Many of the mechanisms that would be needed to establish priced managed lanes were included in the 2007 Tennessee Tollway Act. However, the act was also restricted to exploration of two pilot projects which would require specific legislative approval prior to moving forward. Whether or not a priced managed lane would qualify as a pilot project is unclear. Regardless, if such a project were to be contemplated in the Nashville region it would require coordination with the state legislature through the Tennessee Department of Transportation.

The increasing level of discussion suggests the MPO has opportunities to partner with the state and area transit agencies to raise public awareness and understanding of managed lanes, the various types, how they are supposed to function, and the ways in which they can help address the growing demands on Middle Tennessee's regional transportation network.

Legislative – Federal

MAP-21, the federal reauthorization of the Surface Transportation Act, resulted in some changes that could be relevant to future options for managed lanes in the Nashville region. This included changes to the process and requirements for HOV to HOT conversions. Changes were also made to ensure minimum operating conditions, and to require that all tolling be electronic.

Under previous authorizations, HOV to HOT lane conversion could not occur without a letter of agreement with FHWA. That requirement has been eliminated under MAP-21. However, the state will be required, among other things, to report to the U.S. Secretary of Transportation annually that the operation of the HOV lanes is not degraded (as defined in Title 23, Section 166 of the U.S. Code). Additional requirements must be satisfied prior to conversion, including consultation between the state DOT and the affected MPO(s) and the presence of state tolling legislation. If the MPO wishes to perform a detailed assessment of HOV to HOT conversion, it should coordinate with TDOT, FHWA's Tennessee Division Office, and other appropriate partners to ensure that all Federal, state, and local requirements are met.

Potential Next Steps for Managed Lanes in the Nashville Region

Express Lanes

As defined within this assessment, express lanes, like HOT lanes, may be a viable alternative in the Nashville region. The main difference between express lanes and HOT lanes are the operating rules, particularly those for HOVs. While incorporating HOVs into an express lane does increase the difficulties with enforcement, the benefit of encouraging HOV operations may well offset this increased difficulty.

Reversible Lanes

Reversible lanes require a very specific set of conditions to be considered so that traffic in the off-peak direction is not burdened. Based on traffic data and physical conditions reviewed here, there appears to be opportunities to take advantage of additional capacity in the peak direction to alleviate congestion on selected arterial streets.

Truck Only Toll Lanes

Truck only toll lanes have not been implemented in the United States. Nashville could qualify as an area where serious consideration should be given to truck only toll lanes. However, a separate truck-only facility may be as or more effective than implementing TOT lanes on existing facilities. It is also worth considering whether the greatest improvements to regional mobility, from a comprehensive view, would be developed through special use lanes for trucks, or special use lanes for other vehicles.

Ramp Metering

Ramp metering is widely used throughout the United States. It has the ability to improve flow on all lanes of the facility, not just special use lanes. While ramp metering does often generate some controversy in the public, it is likely that with a strong public outreach and education program, ramp meters could find acceptance in Nashville. Due to its potential of significantly improving traffic flow and mobility, ramp metering should be considered in the Nashville region.

Truck Restricted Lane

Truck restricted lanes are already in use on area interstates, as described earlier. Additional facilities or truck restriction policies may be identified and recommended through freight studies being carried out by the MPO.

Transit Options

Several key corridors in the MPO's 2040 transit vision could be implemented by adding transit-only lanes (perhaps shared with other HOVs) to an existing roadway. For example, the Northeast Corridor would provide a high-capacity rapid transit link among Nashville, Hendersonville and Gallatin via Ellington Parkway, I-65 North and State Route 386.

Recommendations for Future Steps

As previously discussed, there are numerous potential opportunities for lane management in the Nashville region, and no options should be discarded at this point. The question becomes: what should be the first steps moving forward? In deciding that, the potential for significant positive gains must be balanced against costs and risks. For this reason, the steps recommended here build on existing managed facilities in the Nashville region as well as additional strategies that can be brought online without extraordinary cost. Again, though, no options should be discarded at this point. Higher cost strategies, such as additional lanes on the Inner Loop to develop new HOV, HOT, or express lanes may well have a place in Nashville's future. However, for instance, implementation of Hard Shoulder Running may be able to be implemented in a much shorter timeframe and at a lower cost.

Short-Term

- Work with TDOT to continue their program to improve HOV performance/enforcement on the region's existing and planned HOV lanes.

- Look at potential transit improvements, such as new park and ride lots and/or additional routes/shorter headways, to take advantage of improved facilities.

- Open a dialogue with TDOT to discuss the use of Hard Shoulder Running on most of the Inner Loop, including a facility-specific operational study to confirm potential viability and desirability. As part of the constructability analysis performed in this assessment, it was noted that the I-65 bridge over the Cumberland River would require significant improvement in order to handle HSR. However, most commuters into downtown can reach their destinations without traversing the loop's entire length, so this is likely not a fatal flaw.

- Consider performing a study for application of ramp metering to the regional freeway system. Network implementation of a sophisticated ramp metering system may be able to provide significant congestion relief at a good benefit/cost ratio.

Medium-Term

- Implement Hard Shoulder Running, if found feasible and desirable, on the Inner Loop along with required Dynamic Lane Assignment and Variable Speed Limits/Speed Harmonization. The shoulder use could be bus only or mixed transit/single occupant vehicles depending on the results of the study.

- Consider direct access ramps for HOVs/buses at appropriate interchanges.

- Conduct a comprehensive design and operations study for managed lanes in the Nashville region and incorporate recommendations into the MPO's plans and programs.

- Consider HOT operation for HOV lanes.

Long-Term

As the short and medium term plans outlined above are implemented, insight into the integration of managed lane strategies in the Nashville region will be gained. As the effectiveness and acceptance of strategies is better understood, specific facility/strategy pairs for future study and implementation are likely to become evident. Further, population growth, changes in technology, and changes in commuting patterns, the effects of which are currently unknowable will become evident.

While increases in population will increase travel demand, facility capacity may be increased through connected and autonomous vehicles. Also, telecommuting is becoming a viable and growing commute option. As this continues, peak hour demand will be less, perhaps significantly less, than it would be without the telecommute option.

Predicting the future with precision is not possible, however, openness to considering various, reasonable possibilities is possible. By considering facility and network management options, the Nashville region will be in a good position to take advantage of opportunities as the future presents them.

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Appendix A — Managed Lanes Facilities in the United States

Figure 28 — Managed Lanes Facilities in the United States, 2003

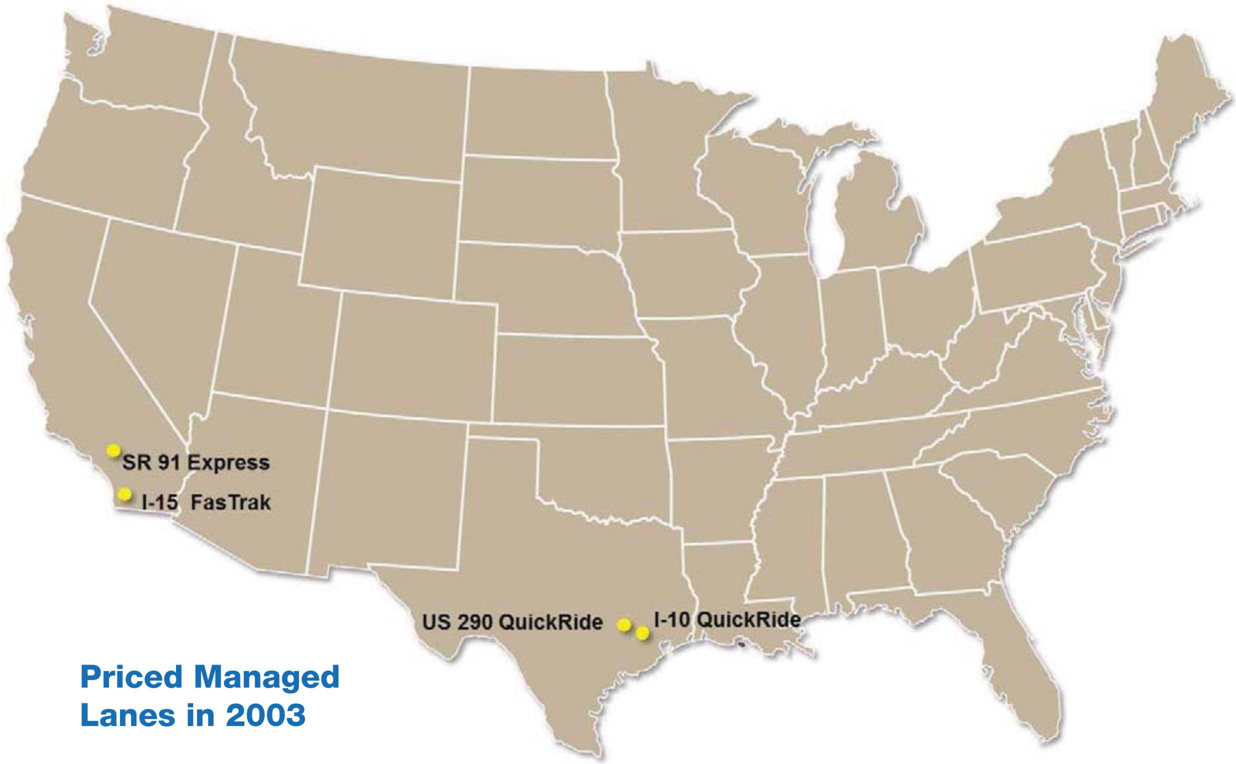


Figure 29 — Managed Lanes Facilities in the United States, 2013

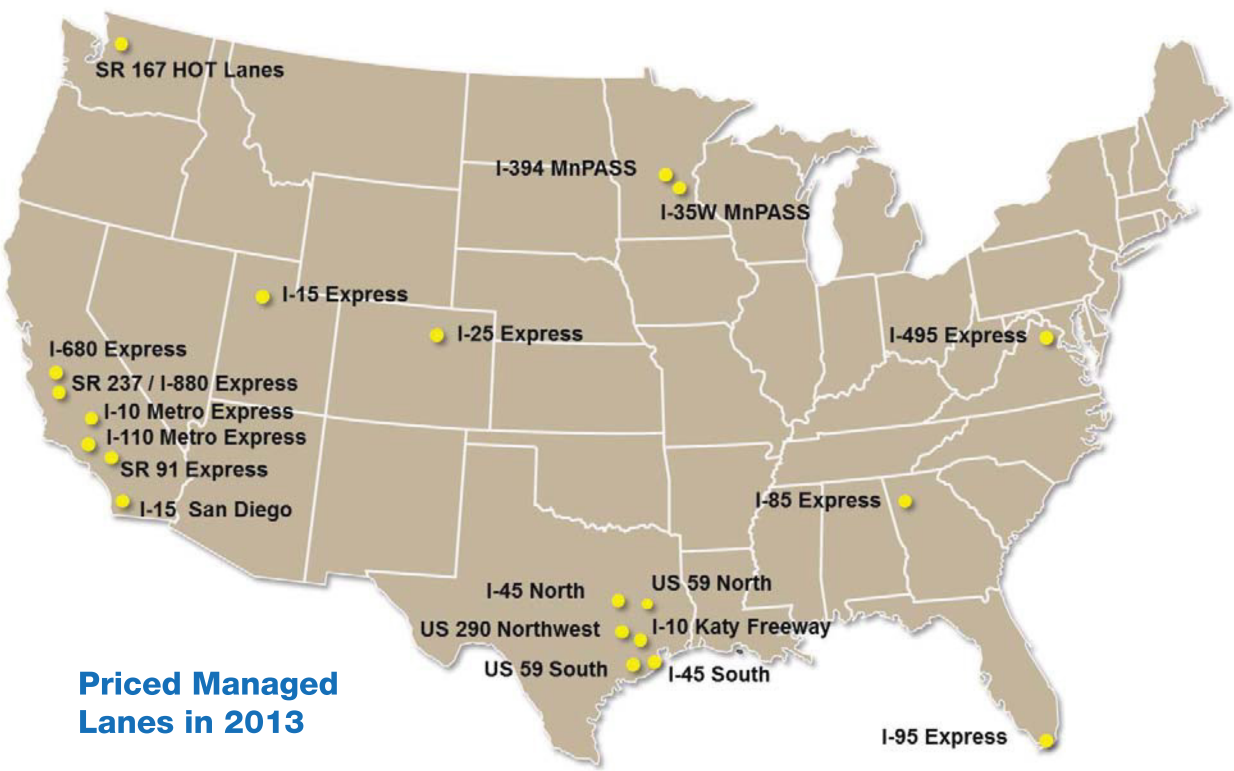
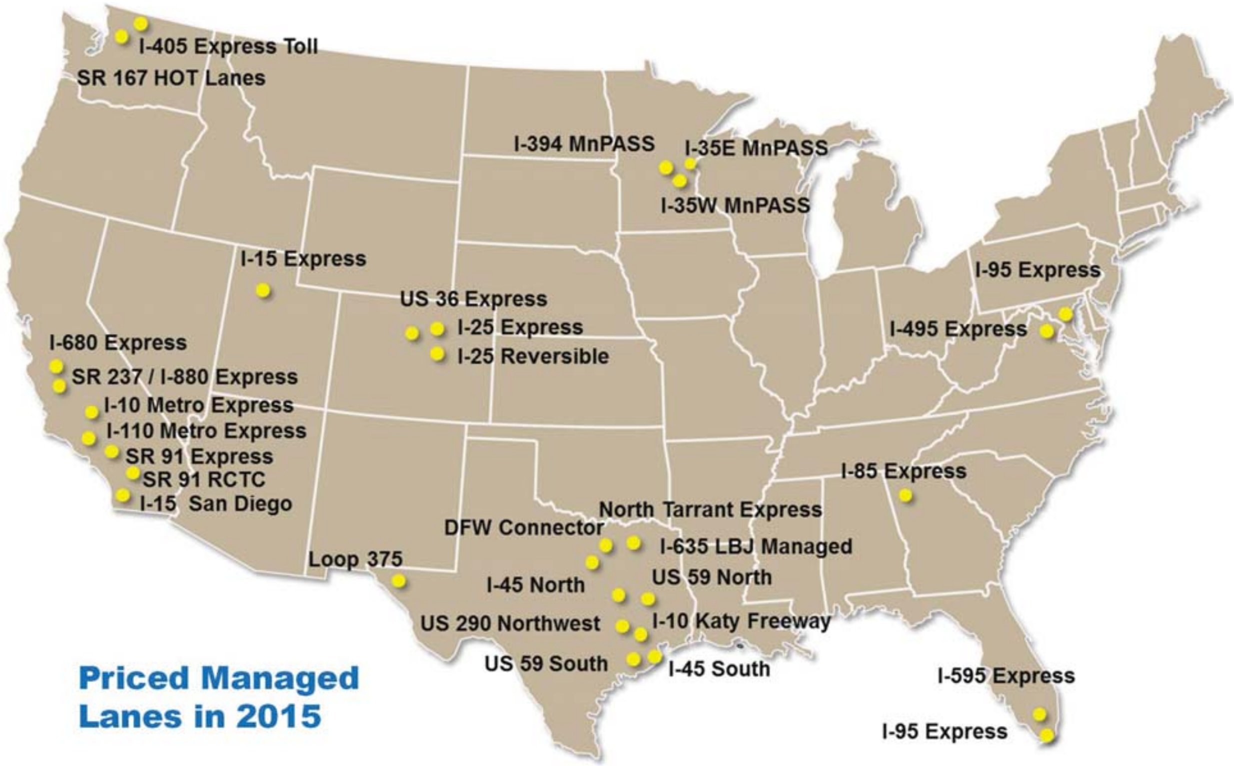


Figure 30 — Managed Lanes Facilities in the United States, 2015



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