100 YEARS TRB
MOVING IDEAS: ADVANCING SOCIETY

CENTENNIAL PAPERS

Standing Committee on *Managed Lanes* (AHB35)
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Managed Lanes: Celebrating a 50th Anniversary at the TRB Centennial

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PURPOSE

As the Transportation Research Board (TRB) celebrates its centennial, the Standing Committee on Managed Lanes (AHB35) similarly reflects on the 50th anniversary of a congestion management practice on urban freeways and streets that involves dedicating lanes for preferential vehicles and travelers. This practice was born out of a realization in many communities that urban roadway demand often exceeds supply and that a need exists to dedicate portions of the roadway for mobility preservation. This paper highlights noteworthy accomplishments of the committee's practitioners who have made contributions on the policy, planning, design, operation, and performance monitoring of these unique facilities; reviews the current state-of-the-practice and envisions what the committee will need to consider within this practice area looking forward.

LEGACY OF MANAGED LANES PRACTICE

While the application of managed lanes dates back almost 50 years and covers early busway, bus lane, and high-occupancy vehicle (HOV) lane treatments, the term "*managed lanes*" was not coined and commonly applied until more recently. The AHB35 committee realized in the mid-1990s that HOV lanes and high-occupancy/toll (HOT) lanes were no longer fully describing all applications, and a more embracing term was needed. While practitioners apply the expression "managed lanes" to a variety of dedicated or preferential lane treatments found on urban freeways and arterials, the public may be exposed to a wider range of terms based on how the projects are marketed and implemented locally.

Definition

The AHB35 committee provided the following definition when authoring the term (*i*):

> *Managed lanes are dedicated lanes or roadways implemented in congested freeway corridors that are actively controlled through a variety of strategies to limit flow rates and thereby preserve an acceptable level of service. By taking such measures, managed lanes generate significant travel benefits, including time savings and improved reliability and operational efficiency to the roadway system. Such lanes can be added either along with new roadway facilities or as modifications to existing facilities; they should not typically be converted from existing general-purpose lanes. Managed lanes can be considered for specific bottlenecks, as corridor treatments, or as networks or systems in a metropolitan region.*

Common examples of managed lanes that are currently in operation include HOV lanes, HOT lanes, preferential bus lanes, dynamic shoulder lanes, and express toll lanes. With latent traffic demand in many urban areas, managed lanes are becoming common solution to help not only manage demand, but also provide a reliable trip when needed. Examples of a managed lanes can be seen in Figure 1. Demonstrating the breadth of managed lane applications, various operational and design strategies can be employed as illustrated in Figure 2. The definition of lane management has changed as has technology expanded. Project operators no longer have to rely on on-site monitoring for HOV lanes, and toll tags have allowed operators to post variable toll rates by time of day or facility. Future technology will allow practitioners to monitor and "control" demand as well. Possibilities for active management continue to expand as technology allows practitioners to monitor real-time traffic conditions, including the ability to monitor individual vehicle and traveler characteristics through common equipment such as toll tags and global positioning satellite (GPS) sensors.

Figure 1: Examples of Managed Lanes on I-95 in Miami (left) and I-110 in Los Angeles (right) Sources: Darren Henderson, Chuck Fuhs and Los Angeles County Metropolitan Transportation Authority.

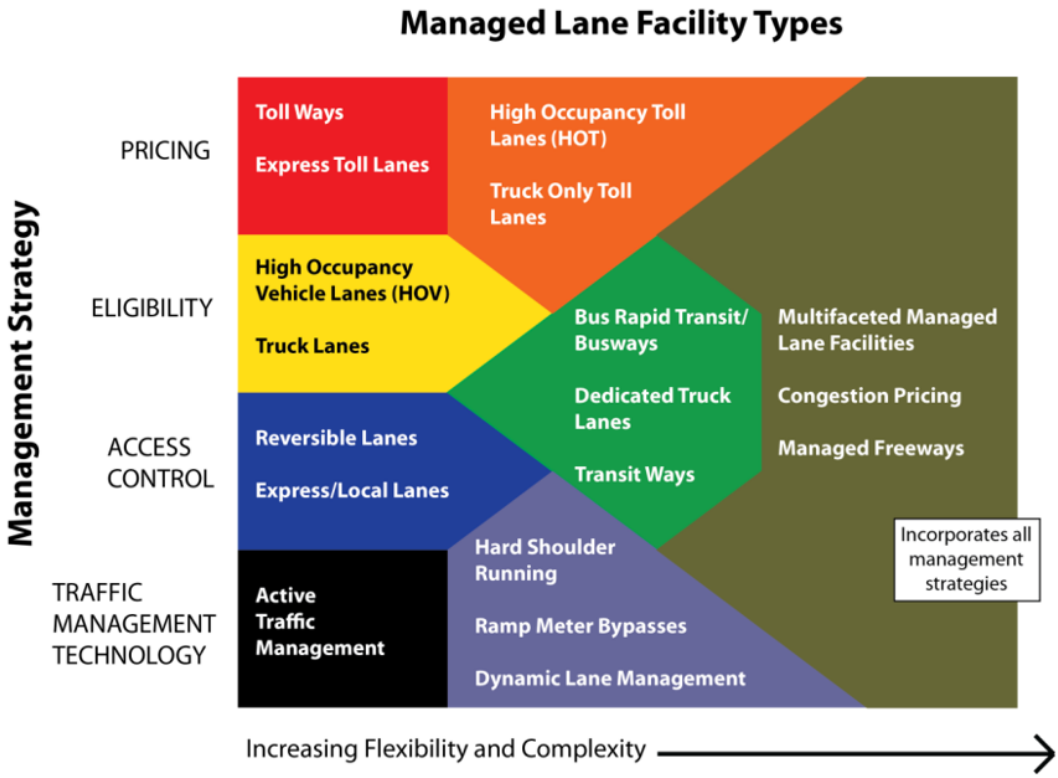


Figure 2: Types of Managed Lanes (Reference 1)

History of Managed Lanes

Managed lanes were first opened around 1970 in Virginia (I-395), New Jersey (Route 495), Washington (I-5 in Seattle), and California (I-10 in Los Angeles). The earliest managed lanes were either dedicated bus or HOV lanes for very high occupancy (4+) vehicles. In the mid-1970s, projects in Los Angeles and northern Virginia broadened used to include vanpools and 3+ occupant carpools. When these projects proved successful, a number of cities took advantage of federal policies encouraging HOV lanes for 3+ occupant carpools and vanpools. By the early 1980s over 125 miles of such facilities were operating in eight states. Metropolitan regions in Arizona, California, Georgia, Florida, Minnesota, Virginia, Texas, and Washington adopted HOV networks where vast portions of their urban roadways had succumbed to recurring congestion and where there were few options to conventionally expand capacity through freeway widening. In many cases, creating dedicated lanes required prudent compromises to the design and operation of the respective freeway. In some cases, newly built freeways incorporated HOV lanes or left such provision in designs assuming latent demand would soon fill up available capacity. Performance monitoring proved that an HOV lane had the ability to move a substantially larger number of commuters in fewer vehicles as well as provide improved trip reliability and travel time savings. Typically, HOV lanes moved the equivalent of 1.5 to 2 general purpose lanes of capacity at comparatively higher speeds. In the extreme, the Route 495 exclusive bus lane in New Jersey moved over 34,000 commuters in a single lane during the morning peak hour (a typical lane carries about 2,000 to 2,200 commuters per hour at maximum flow rates).

Federal, state, and regional policies and funding have been pivotal in advancing this congestion management strategy. Federal funding intended to reduce vehicle emissions, Congestion Mitigation and Air Quality (CMAQ), was a particularly important funding source for the construction of managed lanes. Managed lanes mitigated vehicle emissions by reducing dependence on single occupant travel. In addition to encouraging consideration for HOV lanes, in 1987 the Federal Highway Administration (FHWA) also relaxed funding restrictions to allow managed lanes carrying two or more persons to be considered eligible for funding.

These steps encouraged development of managed lanes projects and systems in many locations, but strategies to manage HOV demand were still limited to access control and eligibility. As a result, some projects suffered from too much HOV demand, while others appeared empty during peak periods. Variable pricing, made possible by electronic toll collection using of in-vehicle transponders, provided another useful tool for lane management. The first such projects to test pricing around 1995 included the I-15 reversible lanes in San Diego and the newly constructed SR 91 managed lanes in Orange County. While the primary benefit of pricing has been to address the shortcomings of lane use or overuse, toll revenues have helped address ongoing managed lane operation and enforcement costs. In addition, net revenues have supplemented funding for bus transit services and related corridor-specific improvements in some cases. More recently, by providing a revenue stream that can be used to attract public and private investors or guarantee debt, variable pricing has been instrumental in addressing a lack of funding for both construction and operation of new capacity facilities in California, Florida, Georgia, North Carolina, Virginia, Texas, Washington, and other states. Federal and state policies encouraging the provision of variable pricing for these dual purposes have expanded opportunities for managed lane networks. Currently over 5,000 miles of projects are in operation in 21 states, two Canadian provinces, and various countries overseas. A large number of projects are in development.

Committee Background

The Standing Committee on Managed Lanes began as a task force sponsored by the Standing Committee on Freeway Operations following two successful national conferences held in 1987 and 1988. The name coined at that time was the High-Occupancy Vehicle Systems Task Force. Founding chairs included Don Capelle and Dennis Christiansen. The committee's primary activities included sponsoring annual meeting sessions and hosting national conferences every two to three years in different major cities in the U.S. and Canada with operational projects. By 1989 the task force was given standing committee status. As technology afforded expansion of management strategies including variable pricing, the committee's charge needed to adjust accordingly. In the committee's 2007 triannual review, a proposal was made to change the name of the committee to "managed lanes" to describe the broadening nature of lane systems beyond HOVs. Two years later the Managed Lane committee's name change was adopted.

The committee has adapted its membership and activities in response to industry changes. In the 1970s, committee activities mainly facilitated collaboration among state DOTs since they, with FHWA, were the main sponsors of the early HOV and bus-lane projects. Today, managed lanes are implemented and operated by a much broader array of implementing and operating agencies from both public and private sectors. As such, committee membership has come to include a diverse range of practitioners from the U.S., Canada, and overseas. Representative state DOTs, transit agencies, metropolitan planning organizations (MPOs), regional mobility agencies, and tolling authorities are represented on the committee. Typically, multiple agencies within a

region partner together to implement and operate managed lanes such as in Dallas-Ft Worth, Atlanta, south Florida, southern California, San Francisco Bay Area, Minneapolis-St Paul, Puget Sound (Seattle area), and northern Virginia.

The committee has found that bringing practitioners together in a variety of forums is an effective way to advance the state-of-the-practice. National and international conferences, symposiums jointly sponsored with other organizations, TRB-sponsored webinars, web-based resource outreach, and young professional engagement have all provided meaningful contributions.

Research plays a critical role in promoting best practices. In 2012, the committee proposed development of a new managed lane implementation guide. The resulting publication in 2016 (NCHRP 835) is the third such treatise developed with committee sponsorship over the years to aid practitioners. Synthesis efforts such as the current NCHRP 20-05/Topic 50-08: Emerging Challenges to Tolling on Price-Managed Lanes are helping practitioners address recently identified issues hindering implementation. The committee also serves as a facilitator for applied research performed by others including the FHWA HOV/managed lane pool fund study, which involves multiple state DOT and local public agency funding sponsors. Such activities continue to evolve to meet the needs of this practice area. The documented evolution this committee has experienced invariably happens throughout the transportation practice and is likely to continue to occur at a perhaps more rapid pace looking forward.

Committee Accomplishments

The Managed Lanes Committee is charged with supporting practitioners and furthering applied research for managed lanes. The committee's most important accomplishments include:

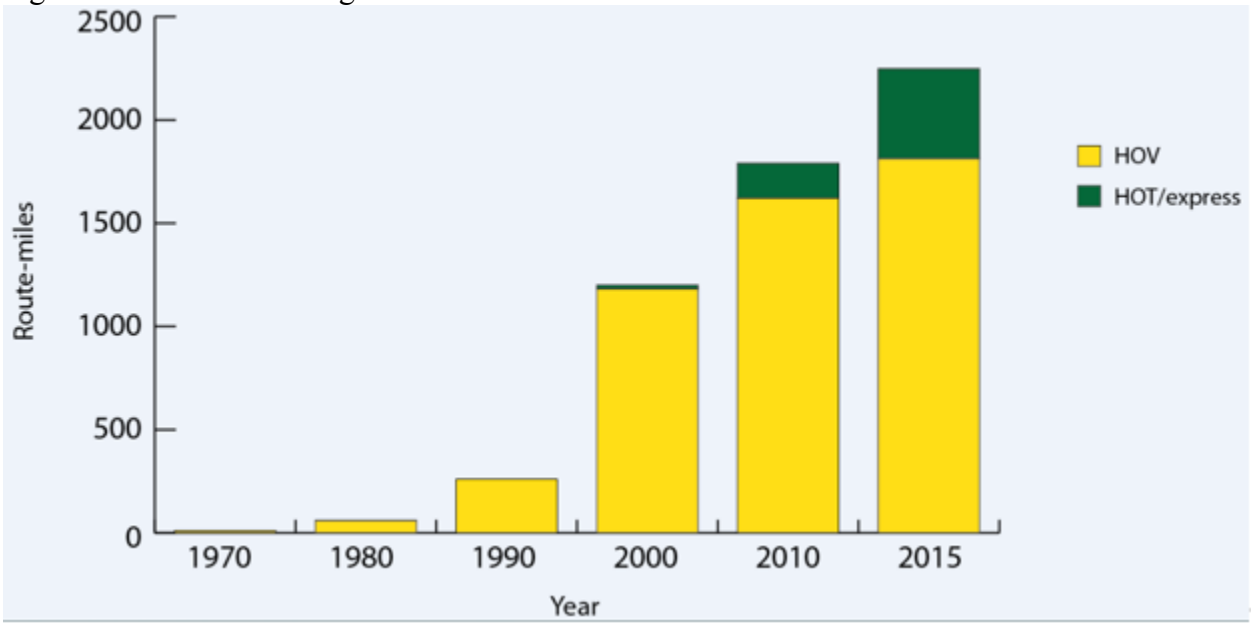
- Proposing and obtaining research funding for three guidance documents sponsored by NCHRP and TCRP
- Research coordination with various FHWA pooled fund study efforts
- Partnering with other committees on many initiatives including annual workshops and technical sessions
- Sponsoring international HOV and managed lane conferences (15 since 1987)
- Jointly sponsoring symposiums with other TRB committees and the International Bridge, Tunnel and Turnpike Association (IBTTA)
- Annual meeting workshops and technical sessions
- Web-based inventories of project information, project announcements, and availability of project reports
- University outreach primarily focused on scholarship grants for papers and posters presented at mid-year meetings
- Co-sponsorship of the Active Traffic Management Subcommittee and Multimodal Pricing Implementation Subcommittee
- Providing responses to questions that arise from project practitioners
- Engaging young members who seek committee affiliation through a young professionals forum

CURRENT MANAGED LANES PRACTICE

The nature of how managed lanes are implemented and operated today greatly differ from the past in many respects. The project sponsors and partners now include a wide array of public and private entities. Initially, state departments of transportation (DOTs), in concert with the FHWA,

were primarily sponsors of HOV lane projects with some transit agency partnering. Today, state, regional, and local transportation agencies, including toll road, regional mobility, transit and MPOs, play a greater role in how projects are conceived, funded, implemented, and operated. Public-private (P3) partnerships are also playing a growing role in concert with state DOTs. Projects traditionally provided a single directional lane primarily for higher occupancy vehicles; today projects address all types of users in multi-lane treatments representing commensurately higher levels of investment. As such, an increasing dependence on tolling to both address variable pricing opportunities to manage traffic and help fund these investments are dual objectives. Systems of managed lanes with direct connections between intersecting routes are planned and being implemented in many locations throughout the U.S., and projects are found in Canada, Spain, Israel, and other countries globally. The growth of managed lanes between 2000 and 2015 doubled U.S. mileage, and projects have continued to open since then (Figure 3). Current plans reflect a continued commitment to invest in these congestion management treatments looking forward.

Figure 3: Growth in Managed Lanes in the U.S.



Source: Texas A&M Transportation Institute and Chuck Fuhs

Current Issues/Needs/Research Gaps

The managed lanes committee works with practitioners within all agencies involved in project development, operation, and monitoring to address issues and needs of the profession. A listing of current issues identified from NCHRP 835 and recent meetings include the following:

- *Equity:* The committee is working on gathering information regarding real and perceived equity issues associated with priced managed lanes. Often referred to as "Lexus Lanes," there is concern that people of lower income will not or cannot afford to pay to use priced managed lanes. In practice, people of all incomes are using the lanes on occasion based on anecdotal data and real data. The committee is looking into research that will address methods and data to examine this issue.

- *Perception and Optics of Priced Managed Lanes:* The committee proposed a NCHRP syntheses topic currently being performed to address challenges that priced managed lanes currently face. Some projects have been deferred or operationally changed. The syntheses will document strategies and tactics employed, lessons learned, and success factors.

- *Occupancy Enforcement:* Technology that improves the potential for automated occupancy enforcement for managed lanes has been an ongoing need dating back decades. Recent tests show inconsistent results or lower accuracy of detection than desired by project operators. The committee continues to work with the industry providers and the public agencies to disseminate information on available technologies and share research that will hopefully lead to improved occupancy enforcement, or even taking the enforcement role out of the equation since priced managed lanes allow all vehicles to use them, many simply at a different price.

- *Separation and Access Configurations:* The committee is gathering data and reports from various managed lanes regarding the impacts to separation and access configurations on planning, design, and operation of managed lanes. Recent corridors with continuous access managed lanes have shed some light on this access configuration when compared to access-restricted managed lanes facilities. Safety-based studies is a subject of future research interest, building on findings from NCHRP 835.

- *Mobile-App based toll systems:* The committee is tracking experiences by member agencies on 1) developing mobile applications that can be used to obtain toll information on a mobile device, or 2) paying the tolls on a mobile device. As part of the broader mobility-as-a-service approach, some agencies are considering integrating paying the toll and the managed lanes trip time information as part of the mobility application platform.

- *Interoperability*: Efforts are still underway to provide interoperability amongst the toll systems in various states and comply with MAP-21 federal legislative requirement. Some vendors are marketing a universal transponder compatible with all existing electronic toll systems. While full interoperability has not been achieved yet, interoperability agreements have been signed to allow state-specific tags to be more widely used in various other states. States are forming regional "hubs" that will use license plates and other toll account information to provide interoperability within hub members and eventually among different hubs. For example, California, Oregon, Washington State, Utah, and Nevada are working through a single hub that will eventually be connected with a hub based in Colorado. The committee will continue working with the toll industry in identifying the challenges and the opportunities that interoperability brings to tolling on priced managed lanes.

Current research priorities the committee has pursued include the following:

- Data for system performance
- Dynamic traveler information for managed lane systems
- Advanced Traffic Management and managed lanes for automated and connected vehicles
- Transportation demand management strategies
- Geometric design including access and separation topics

- Understanding facility attractiveness and consumer choice
- Enforcement efficacy

Mission Alignment with Other Committees
The Committee has partnered with other TRB committees in research and events including conferences, annual meeting sessions and workshops over the past three years as noted in Table 1. The committee seeks to partner on the larger list of committees based on mutual interest, including identification of research needs and development of research proposals; and joint sponsorship of events with common interest. As managed lanes evolve other TRB committees will undoubtedly need to be partnered with.

Table 1: Committees and Subcommittees with Common Interests (Recent Partnered Committees in **BOLD**)

Number	Name	Common Interests
ABE25	**Congestion Pricing**	Tolling, revenue, and financing for managed lanes
AHB20	**Freeway Operations**	Freeway operations and traffic management, combined operational strategies on controlled access highways
APO50	**Bus Transit Systems**	Express bus operations on managed lanes
ABC30	Performance Measurement	Performance monitoring on managed lane
ABE50	Transportation Demand Management	Managed lanes are one of their TDM components
ADA60	Public Involvement in Transportation	Marketing and education on managed lanes
ADB10	**Traveler Behavior and Values**	Modal and spatial shifts caused by changes in travel behavior on managed lanes
AHB40	Highway Capacity and Quality of Service Committee	Access and capacity associated with managed lanes
AHB45	Traffic Flow Theory and Characteristics	Access and capacity associated with managed lanes
AHB15	Intelligent Transportation Systems	ITS features on managed lanes (metering, CCTV, DMS pricing, and travel time information)
ADB40	Transportation Demand Forecasting	Demand for managed lanes
AP020	Emerging and Innovative Public Transport and Tech	New emerging and innovative concepts of public transport systems and technologies.
AHB10	**Regional Transportation Systems Management and Operations**	Incident management, enforcement, and operations management on managed lanes
AHB30	**Vehicle-Highway Automation**	Potential use of managed lanes for autonomous vehicle operations (no current applications being tested)
AFB10	**Geometric Design**	Design of managed lanes, particularly concurrent lane separation and access features

AHB65	**Operational Effects of Geometrics**	Research related to operational impacts on control access highways, including managed lanes
AP025	Emerging Ridesharing Solutions Joint Subcommittee	Research related to emerging solutions for increasing the average occupancy of private vehicles
AL040	Emerging Technology Law Committee	Dialogue on consideration of legal aspects of emerging technologies such as automated and connected vehicles in managed lanes
AP010	Transit Management and Performance Committee	Dialogue on the management and performance of transit on managed lanes

Joint subcommittees are co-sponsored by the Managed Lanes Committee with other committees where there are common interests. They currently include:

- Joint Subcommittee on Active Traffic Management: This subcommittee is co-sponsored with the Freeway Operations Committee. It serves as a forum for researching, promoting, and evaluating real time traffic management tools, which are frequently deployed in conjunction with managed lanes.
- Joint Subcommittee on Multimodal Pricing Implementation: This subcommittee is co-sponsored with the Congestion Pricing Committee. It serves as a forum for researching, promoting, and evaluating congestion pricing projects, including priced managed lanes, with an emphasis on multi-modal projects.
- Simulation Subcommittee: This subcommittee is sponsored by many other committees to better represent traveler behavior in simulation models during the planning process.

LOOKING FORWARD

Legacy over the last 50 years reflects managed lanes practice evolving as an operational strategy to provide more vehicle and person throughput than general-purpose lanes, largely on controlled access facilities. Technology adoption in the past has resulted in "inflection points" in which the tools to manage traffic have changed. For example, two important infection points were the transponder and the GPS applications allowing for variable pricing to be employed as a traffic management tool. In December 1995, the first priced managed lanes were implemented in southern California, ushering in an era where pricing could be used in addition to access and vehicle eligibility as a means of demand management. Today, there are nearly 50 priced managed lanes in operation in some of the most congested urban corridors in the U.S.

As the committee looks to the near-term and long-term future of this practice, a number of such inflection points are likely. Another potentially key year along the evolutionary path of managed lanes could be 2007. The first version of the iPhone was released in that year; and while mobile phones and other personal digital assistants (PDAs) existed before it, the release of the iPhone and associated apps architecture continue to revolutionize many sectors of the U.S. and world economies, including transportation. If not for the iPhone and other contemporary competitors in the mobile phone space, it is unlikely that Uber, Lyft, Bird, Lime, and other recent transportation services would have been created. These providers stand ready to test the paradigms involving car ownership, vehicle navigation, and the currently accepted methods of

transportation revenue. While a straight line cannot be easily drawn from the release of the iPhone to the evolution of managed lanes, practitioners will need to recognize how the smartphone has revolutionized the transport space and more importantly the average person's expectations of what they should get out of and value in the transport sector. More than ever today, people simply want the transport sector to work and expect some certainty of reliability even if roadways are congested. This willingness to try and accept new business models in the transport sector is and will continue to be key in the evolution of managed lanes. An underlying uniqueness of the priced managed lanes are the specific customization of each facility to meet the needs of the community that it is serving. Factors that could mute some technology adoptions may be the need to protect data privacy and security in order to address acceptance, functional efficacy, concerns addressing equity, sponsoring agency risk, and depth of technology adoption.

The expansion of the modern mobile communications/computation infrastructure is one major factor that will guide the future evolution of managed lanes. Other factors that will influence this evolution over the next two decades will be the continued electrification and automation of the U.S. vehicle fleet. Electrification will continue for many reasons (e.g., economics, lower operation cost, public responsiveness, climate change policies, etc.); including agency objectives that encourage the implementation of connected and automated vehicles (CAVs). For CAV progress to be made in a substantial way, the vehicle fleet appears likely to move towards electrification. Like the release of the iPhone, while the electrification of the vehicle fleet and CAV progression may not directly impact the evolutionary path of managed lanes, this will continue to apply downward pressure on the ability of traditional fuel taxes to fund transport infrastructure and offer further opportunities to manage vehicle flow. Outcomes could include more and a higher variety of user fees, charges, and costs to receive chosen benefits/services.

This sustained transport funding gap will mean that local, state, and federal leaders will continue to seek alternative means to deliver the transportation infrastructure necessary to provide improved mobility, greater route choice, improved safety, reduced environmental footprint mitigating impact, better use of resources, increased operational efficiency, and generate revenue. They may also continue to seek alternate funding sources to close funding gaps. The current variant of managed lanes that includes pricing will continue to be attractive to public transportation leaders in the near-future because of its ability to generate revenue along with its operational benefits.

While the evolution of managed lanes does not directly depend on increased implementation of CAVs (in terms of both vehicle penetration rates and CAV complexity), CAVs can benefit from managed lanes and will likely accelerate the public's acceptance of and desire for future versions of managed lanes. As CAV implementation advances, there may be concern around how increased percentages of CAVs could impact the land-use patterns of metropolitan areas. Some urban planners believe that as travel by CAVs lessens congestion and/or the burdens of congestion (e.g., allowing for productivity to occur while traveling in CAVs that are still operating in congested conditions), people will continue to reside further away from employment centers, potentially reinforcing long commute trips.

In 1996 (the last major inflection point that influenced managed lane practice), no one would have predicted the release of the iPhone in 2007. Likewise, in 2019, it is hard to imagine what technology will look like a decade from now. If technology continues to only advance incrementally relative to what exists today, it will be more than powerful and robust enough to support the future transport sector and more specifically managed lanes operations and increased

applications of roadway pricing in one or many forms. As practitioners look farther out in the future, it is more likely that managed lane innovations will be driven by traditional market forces and urban development needs rather than by technological advances. Maybe better said, the future for managed lanes may not require robust technological advances but can only be helped by them.

While existing managed lanes perform markedly better to their general-purpose lane counterparts today, they still face hurdles. Such hurdles include equity, multi-segment pricing, terminus conditions, tying lanes into networks, integration with larger transport networks, ability to respond to changing land-use patterns, and the impact of shared mobility. Existing priced managed lane projects and systems will continue to be stressed by policy restrictions and geometries that overload them, likely causing them to periodically break down and thus, failing to produce operational benefits.

As practitioners look further out in time, it is not impossible to imagine the evolution of priced managed lanes being influenced by at least four factors: (1) continued electrification of the vehicle fleet applying downward pressure on traditional transport funding; (2) continued implementation of new mobility models impacting urban, suburban, and ex-urban land use patterns; (3) priced managed lanes decreasing in operational performance due to increased demand and interface with the surrounding transport networks; and (4) mobile telecommunications and computing technology continuing to grow and allow for more innovation and choices in the transport sector. Experiences from other countries also promote a vision for connected vehicles in which all travel lanes are managed, thus dedicating a subset of the roadway for managed lanes may be relegated as less relevant.

What this means for the future is that the confluence of these factors could result in greater transport network or corridor pricing (e.g., interstate pricing), some regions or states implementing mileage-based user fees (i.e., roadway usage pricing), and some dense urban areas implementing cordon pricing. While it is difficult to know exactly what future variant of roadway pricing will emerge or if various variants will emerge in different areas—what is more certain is that priced managed lanes will continue to evolve in usage and sophistication in major metropolitan areas, and that the existing investments will likely play a primary role in sustaining urban mobility for many decades to come.

i Guidelines for Implementing Managed Lanes, NCHRP 835, National Academy of Sciences and Medicine, Washington D.C., 2016.