TOLL-MANAGED LANE PIONEERS: LESSONS FROM FIVE US STATES

Emily Swimmer,[1] Carter B. Casady[2]*, and Jose A. Gomez-Ibanez[3]

ABSTRACT

Toll-managed lanes have become an increasingly popular technique among transportation policymakers for managing congestion on existing highways and, in some cases, financing the construction of new lanes in congested urban corridors. Although growing in popularity, the adoption of these facilities is concentrated in five states: Texas, California, Colorado, Minnesota, and Florida. This paper examines the adoption and utilization of toll-managed lanes in these pioneer states. Using archival, case-based research, our analysis suggests that the adoption of toll-managed lanes was driven by a combination of factors, including rapid population growth, near or above average growth in vehicle miles traveled (VMT), and insufficient gas tax funding for transportation investments. Implementation was also generally similar across states but some of the pioneers delegated the management of their toll-managed lane programs to special regional highway authorities while others used state highway agencies.

KEYWORDS

Managed lanes; transportation; public-private partnerships (PPPs); tolls; case studies

[1]Master of Urban Planning, Harvard University, USA, 925-322-3835, emarsh@gsd.harvard.edu

[2]PhD Candidate, Civil and Environmental Engineering, Stanford University, USA, 310-592-8163, cbcasady@stanford.edu; *Corresponding author

[3]Professor, Urban Planning and Public Policy, Harvard University, USA, 617-495-1341, jose_gomez-ibanez@hks.harvard.edu

1. INTRODUCTION

Toll-managed lanes are lanes which operate adjacent to the general-purpose lanes of an expressway to optimize traffic capacity, free flow speeds, and/or trip reliability (FHWA 2012; FHWA 2017b). Access to toll-managed lanes is usually restricted by vehicle type and/or occupancy, special lane entrances and exits (e.g. express, contraflow or reversible), and tolls/congestion charges which vary according to traffic patterns throughout the day.

Toll-managed lanes typically take one of two distinct forms. The first type utilizes tolling largely to regulate congestion rather than to finance facility expansion. This type is often the product of the conversion of existing and underutilized High Occupancy Vehicle (HOV) lanes to High Occupancy Toll (HOT) lanes. Used to primarily manage congestion, these HOT lane conversions restrict access to toll-paying motorists and high occupancy vehicles, such as carpools or buses, who received a toll discount or exemption.

The second type of toll-managed lanes are designed to raise revenue to finance lane construction as well as control congestion. These toll-managed lanes typically do not allow high-occupancy vehicles discounted or free access to the lanes. Moreover, because purpose-built managed lanes are usually very costly, private concessionaires are sometimes contracted via public-private partnerships (PPPs) to build, finance, and operate these facilities for a fixed term, usually of 30 to 50 years (FHWA 2016a). In either form, toll-managed lanes that are appropriately planned and implemented can reduce congestion and deliver faster travel times.

The congestion-relief benefits of toll-managed lanes were first demonstrated in the US when the State Route (SR)-91 Express Lanes in California opened in the early 1990s. Although the concept of tolling lanes had already been around for decades, SR-91 kindled the interest in managed lanes as viable, toll-based congestion management technique. After California's legislature passed legislation in 1989 which enabled California's Department of Transportation (Caltrans) to contract with private concessionaires and collect tolls from motorists on expressways, SR-91 was built by private investors alongside and within the existing right-of-way of the SR-91 freeway. The $125 million, ten-mile facility was awarded by the State of California as a build, own, operate concession for 35 years. The original contract prohibited adding capacity to the adjacent SR-91 facility in an effort to eliminate competition. This lead to the buyout of investors by Orange County before the contract termed but the SR-91 managed lanes generated, at their peak, upwards of $40 million in revenue per year.

Since the opening of SR-91, transportation policy makers across the United States have increasingly used toll-managed lanes to improve the use of road capacity on existing expressways and/or finance the construction of new lanes in congested urban corridors (Pool 2014; Fitch 2018). While only two additional managed lane projects were deployed in the United States within the first ten years after the opening of SR-91, by 2010, the number in operation had increased to nine. By 2018, this number had exploded to 48 (see Figure 1).

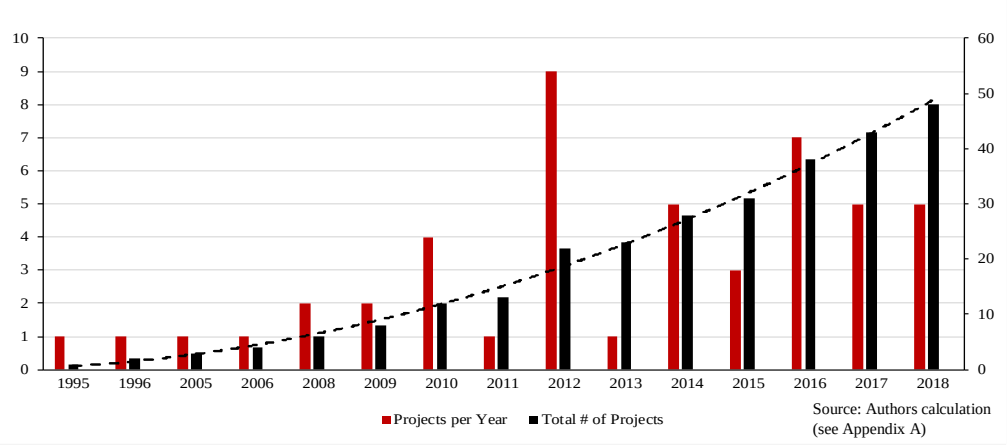

Figure 1: HOT Lane Facility Openings in US (1995 – 2018)

To date, many more projects are currently in planning or under construction (see Appendix A).

Additionally, the early adoption of managed lane facilities was primarily concentrated in five states: namely Texas, California, Colorado, Florida, and Minnesota (see e.g. TRB 2019). As the utilization of managed lanes expands to other states, it is important to reflect on how these five pioneer states embraced the managed lane concept. In this paper, we thus aim to address the following research question:

(1) What economic, political, and social factors motivated the adoption of toll-managed lanes in these pioneer states?

In the following section, we begin with a brief history of toll-managed lanes in the United States. Next, we examine the adoption of toll-managed lanes in the five pioneer states. Finally, we provide a short discussion of the similarities and differences in toll-managed lane implementation among these states.

2. A BRIEF HISTORY OF TOLL-MANAGED LANES

For almost a century, federal and state motor fuel taxes have been the major source of funding for highway construction and maintenance. In 1956, Congress established the Interstate and Defense Highway System, a road network of 32,000 miles to be built and maintained by the states with the inducement of federal grants to cover 90 percent of the construction cost. The grants were funded by a federal tax on fuels, and Congress prohibited the states from collecting tolls on the Interstates on the grounds that motorists had already paid for them through the federal fuels tax. The only exceptions were roughly a dozen toll roads in the East that were grandfathered into the Interstate System. At the state level, there was also popular resistance to tolling state highways that were not part of the Interstate System on similar grounds.

As traffic increased on the Interstate System, transportation policy makers began deploying HOV lanes to manage growing congestion. While HOV facilities were first deployed in World War II as part of a fuel rationing program, they did not reappear until the energy crises of the early 1970s as exclusive bus lanes (FHWA 2016b, 2017a). The pioneers included a bus-only lane on the Shirley Highway in northern Virginia and contra-flow bus lanes on the approaches to the Lincoln Tunnel between New York and New Jersey. In many cases, the bus lanes increased public transit ridership, as intended, but not enough to use more than a small fraction of the lane's vehicle carrying capacity. Motorists stuck in the congested general-purpose lanes were often angered to observe only a few buses per minute whiz by in the adjacent bus lane. To improve utilization, the bus lanes were initially opened to carpools of three or more people (HOV3+) and later, if there was still capacity, to carpools of two or more (HOV2+). These changes saw "many HOV lanes . . . outperform adjacent general-purpose highway lanes in terms of person throughput, especially during peak hours of service" (FHWA 2017a, 1-1). However, large portions of America's 2,500 lane-mile HOV network still experienced "mild to severe underutilization or overcrowding or both, depending of prevailing traffic conditions" (FHWA 2017a, 2-1).

With HOV lanes "not meet[ing] expectations about congestion relief benefits," interest in tolling revived in the 1980s and 1990s (FHWA 2017a, 1-1). By then, the Interstate System was essentially complete but state and local governments were looking for sources of revenue to fund the rehabilitation of older segments as well as the extension of expressways to areas where the original Interstate planners had not anticipated development. Anti-tax sentiment in the 1980s made it increasingly difficult to raise federal or state fuel taxes, even though the proceeds were often earmarked for transportation. Moreover, transportation planners were becoming

increasingly interested in the potential for using pricing (e.g. tolls) to manage severe congestion on existing highways instead of building costly new capacity.

Over the last decade or two, Congress has relaxed restrictions for tolling on Interstate highways to some degree. For example, with special permissions from FHWA programs, tolls can now be collected on bridges that are being rebuilt, applied to HOV lane conversions, and used when existing Interstates are rebuilt and/or widened as long as the number of un-tolled lanes is not reduced. When coupled with the development and spread of electronic toll collection and video enforcement technologies, these relaxed restrictions have enabled transportation planners to explore new active demand management (ADM) techniques. While ADM encompasses a variety of different ways to "[use] information and technology to dynamically manage demand" by time of day or by actual levels of congestion in order to maintain free flow speeds (FHWAb 2017b)[4], toll-managed lanes—i.e. high occupancy toll (HOT) lanes, Express Toll Lanes (ETLs), Value Pricing Lanes, and smart roads—have become one of the most popular ADM strategy among transportation agencies in recent years. Although toll-managed lanes initially got off to a slow start after their practical demonstration in California on SR-91, an average of roughly five new facilities opened per year between 2010 and 2018. Today, most operating toll-managed lanes remain concentrated in our five pioneering states.[5]

3. CASE ANALYSIS: PIONEER STATES IN TOLL-MANAGED LANE ADOPTION

We utilize a case study research design to help us understand why and how these states became toll-managed lane pioneers (Yin 2017). We rely on archival records from various mediums, including academic manuscripts, government reports, news articles, databases, and other print/online sources. Our approach remains exploratory given that time and space requirements preclude us from providing an overly detailed historical account of toll-managed lane adoption in these five pioneer states. Finally, because the vast majority of today's currently operating managed lane facilities opened prior to 2017 and many new project have been extensions of existing facilities, our case analysis focuses primarily on the formative years of managed lane adoption (i.e. 1995 – 2016) rather than more current developments in each state (i.e. 2017 – 2019).

3.1 TEXAS

By the early 2000s, Texas faced increasing highway maintenance and construction needs as its metropolitan populations grew while the overall revenue from the state's gas tax declined due to inflation and improving fuel efficiency of cars (Williamson 2010). Because raising the gas tax was not a politically viable option, Texas sought alternative methods for delivering needed highway improvement projects, including both reconstruction and expansion of existing highways and construction of new highways. In 2000, the Texas Transportation Institute, with support from the Texas Department of Transportation (TxDOT) and FHWA, launched a study to provide preliminary guidance on how to plan and operate managed lanes in Texas. In 2003, the legislature passed several bills that authorized Texas transportation agencies to create HOT lanes and to pursue alternative financing mechanisms (Kuhn et al. 2005). Most notably, House Bill 3588 enabled transportation agencies to use new financing mechanisms aimed at accelerating project delivery and generating additional cash flow, which included comprehensive development agreements with private entities. This allowed private entities to

[4] Other ADM strategies include dynamic fare reduction, dynamic HOV lanes, dynamic pricing, dynamic ridesharing, dynamic routing, and dynamic transit capacity assignment as well as on-demand transit, predictive traveler information, and transfer connection protection (FHWA 2017b).

[5] Within the last two years, Georgia has added a few additional corridors to its network. They are not one of our pioneer cases.

fully design, build, operate, and finance toll roads. Further, the bill authorized the Texas Transportation Commission to create regional mobility authorities (RMAs) to enable localities to approve and generate revenue from regional transportation projects. Revenue from these projects could also be used to fund future infrastructure investments (Ellis et al. 2014).

Before the passage of the legislation in 2003, the Katy Freeway (Interstate Highway 10), a highly congested freeway in Houston, had already been assessed as obsolete by TxDOT with, "maintenance costs at four times the average expressway segment and inadequate to carry the 200,000 vehicles daily demand" (Goodin et al. 2013). In 1998, in advance of HOT lanes legislation, TxDOT piloted a QuickRide Program, which allowed single occupancy vehicles to use the HOV lanes for $2 per trip. The pilot was effective in relieving congestion in the general-purpose lanes and provided customers with a choice of how to travel during commute hours. Given the limited available transportation funds and recent Texas legislation, TxDOT elected to implement HOT lanes on the Katy Freeway in order to fully reconstruct a 12-mile portion of the roadway. The Metropolitan Transit Authority of Harris County (METRO) assumed responsibility for financing, constructing, operating and maintaining the managed lanes portion of the freeway, while TxDOT maintained responsibility for operating the general-purpose lanes (Goodin et al. 2013). The Harris County Toll Road Authority (HCTRA) then joined this partnership between TxDOT and METRO and implemented three HOT lane projects in the Houston metropolitan region. It also extended two of these facilities.

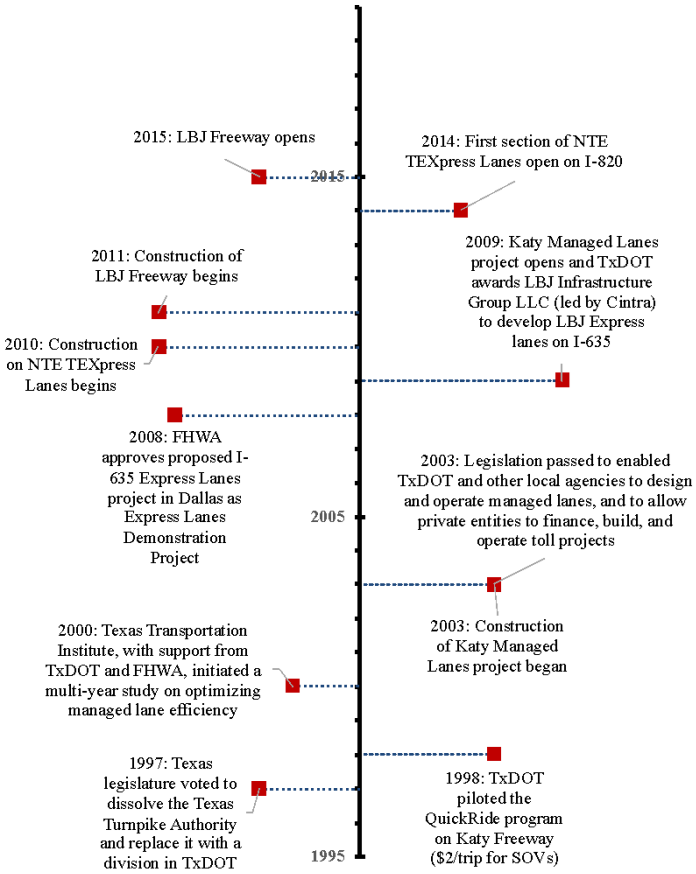

Figure 2: Texas' Initial Managed Lane Milestones

HOT lanes projects have also become common in the Dallas area. These projects, however, are primarily being implemented through PPPs. The history of HOT lanes in north Texas begins with the Texas Turnpike Authority (TTA), which was formed in 1953 to construct and operate the Dallas-Fort Worth Turnpike. Although, the agency was tasked with constructing toll roads throughout Texas, the bulk of its projects were constructed in the Dallas-Fort Worth metropolitan region. In 1997, Senate Bill 370 converted the TTA, which had been an independent state agency, into a division of TxDOT. The same bill established the North Texas Tollway Authority (NTTA) as the regional toll authority and transferred all of TTA's assets

and liabilities to the NTTA.[6] As the local toll authority, NTTA is tasked with financing, constructing, and overseeing turnpike projects in the region. Under Senate Bill 370, NTTA has the first option to develop planned toll roads. When it is not feasible for NTTA to construct a toll road, however, the agency may waive its primacy (NTTA 2017), which it did in the cases of the Dallas' North Tarrant Expressway and LBJ Freeway.

By the early 2000s, the 10-lane LBJ Freeway (I-635) in Dallas reached its peak capacity of 270,000 vehicles per day and TxDOT estimated that demand would eventually increase to 500,000 vehicles per day. The roadway needed to be expanded, but, given limited public funding, there was a risk that the project would be delayed or never built (Williamson 2013). TxDOT submitted a proposal for the LBJ Freeway to be included in FHWA's Express Lanes Demonstration Project, which was approved in 2008 and allowed TxDOT to manage congestion on the aging LBJ Freeway using HOT lanes. Due to limited public funding, TxDOT elected to rebuild the freeway as a PPP. TxDOT competitively awarded the contract, which includes a 50-year concession agreement, to the LBJ Infrastructure Group, led by Cintra, and construction began in 2011. In the same time period and for the same reasons, NTTA elected to relieve congestion on North Tarrant Expressway (I-820) by constructing HOT lanes along a 12-mile section. As with TxDOT and the LBJ Freeway, NTTA decided to construct this project, NTE TEXpress Lanes, as a PPP and awarded the contract to the NTE Mobility Partners, a consortium between Meridiam Infrastructure, Cintra[7], and North Tarrant Infrastructure LLC—i.e. joint venture between Ferrovial Agroman US Corp. and Webber LLC). The first section of NTE TEXpress Lanes opened in 2014.

Since the initial reconstruction of the LBJ Freeway and NTE TEXpress Lanes, LBJ Infrastructure Group/NTE Mobility Partners has been implementing a system of HOT lane facilities across the Dallas-Fort Worth metropolitan region, including the expansion of the NTE TEXpress Lanes (Sanchez 2016; see also Appendix A). As of 2017, there were a total of four HOT lane facilities in the Dallas-Fort Worth Area with five more projects underway (four are facility extensions) (FHWA 2017c). In total, Texas has constructed over 130 miles of HOT lanes in the Houston, Dallas - Fort Worth, and Austin metropolitan regions since its first toll-managed lane project opened in Houston in 2009. In Austin specifically, the Central Texas Regional Mobility Authority is slowly building out another network of managed lanes. To date, Austin has four operating facilities, three under construction, and three under development (see, e.g. CTRMA 2019). Like Austin, Texas' broader network of managed lanes continues to expand.

3.2 FLORIDA

The first toll-managed toll lane in Florida opened in 2008 on Interstate 95, which cuts through Miami-Dade, Palm Beach and Broward Counties. By 2014, the toll-managed lane on Interstate 95 had been extended twice and now totals 22 miles. As of 2017, Florida is constructing four additional toll-managed lane projects on three new facilities, two of which are in Miami-Dade County and the other two in Northeast and Central Florida (FHWA 2017c). Florida is also in the planning stages for two additional projects in Tampa and Northeast Florida.

The groundwork for toll-managed lanes in Florida began in 2002 when Governor Jeb Bush signed House Bill 261, which created Florida's Turnpike Enterprise (FTE), a business unit of the Florida Department of Transportation (FDOT), to manage and operate tolled highways throughout Florida. Governor Bush directed the FTE "to pursue innovation and best private-

[6] NTTA was the only regional toll authority established in Texas as a result of this bill. In addition to this regional toll authority, Texas has seven county toll authorities (such as HCTRA) and eight regional mobility authorities that have a similar structure as the NTTA.

[7] Cintra is a subsidiary of Madrid-based Ferrovial.

sector businesses practices, to improve cost-effectiveness and timeliness in project delivery, to increase revenues and expand its capital program, and to improve quality of service to its customers" (IPFS 2016). Florida's Office of Toll Operations was merged into the newly created FTE. In 2017, FTE managed 600 miles of roadway and 80 percent of all Florida tolled facilities.

In 2003, FDOT hired Robert Poole, toll-managed lane advocate and the founder of the Reason Foundation, to study the viability of toll lanes in South Florida. In 2008 Poole published a report titled "A Managed Lanes Vision for South Florida," which became "a primer for toll lane plans across the state" (Barton 2014). The report envisioned toll lanes throughout the Miami area by 2030. Poole's report specifically identified Interstate 95 as a candidate for a toll-managed lane because congestion during peak hours was so high that its single HOV lane was overcrowded with an average speed of 18 mph. FDOT, in partnership with USDOT and FTE, moved forward with this project and opened its first toll-managed lane on Interstate 95 in Miami in 2008 (see e.g. FDOT 2010, 2011, 2013). Although I-95 was implemented by FDOT rather than the then newly-created FTE, this first toll-managed lane project was put forth because FDOT, like FTE, was seeking alternative strategies for addressing increasing congestion and funding new capital projects.

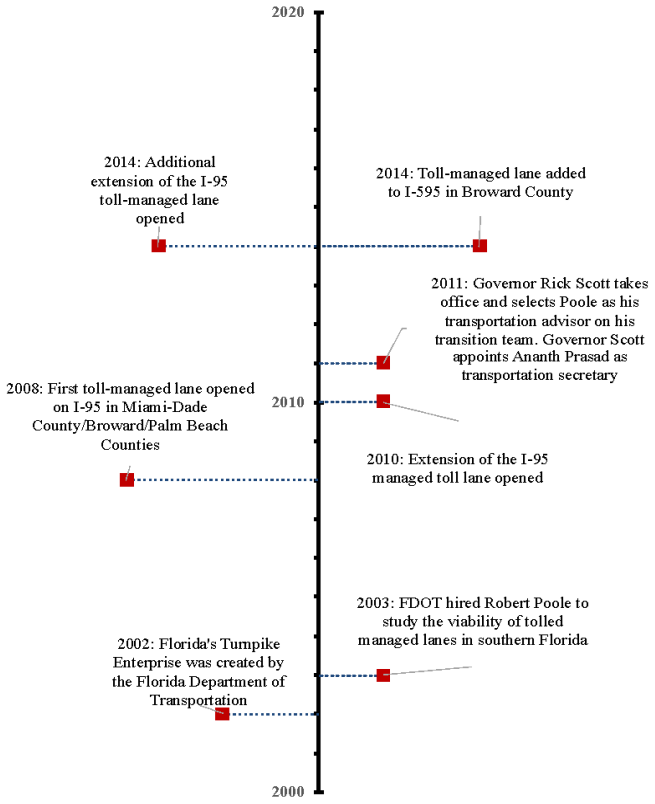

Figure 3: Florida's Initial Managed Lane Milestones

When Governor Rick Scott was elected in 2011, he selected Poole as a transportation advisor for his transition team. With the success of the I-95 project and revenue from gas taxes on the decline, toll-managed lanes were solidified as Florida's strategy for transportation funding. Poole expanded on his 2008 managed lanes report and published a second report outlining a network of toll lanes in southeast Florida connecting Miami-Dade, Broward, and Palm Beach counties. As of 2017, the state was pushing ahead with plans to toll portions of Interstate 4 in Orlando, Interstates 275 and 75 in Tampa and extend the existing toll facilities on Interstate 95 in Miami into Broward County (Hannan 2012).

3.3 MINNESOTA

Minnesota opened its first toll-managed lane on Interstate 394 in 2005 (FHWA 2010). Minnesota opened its second managed toll lane project on Interstate 35W in 2009 and its third project on Interstate 35E in 2016. As of 2017, Minnesota's network of express lanes, called MnPass, includes 60-lane miles of roadway (FHWA 2017c).

I-394 became a candidate for toll-managed lanes in 2001 when a study completed by the Minnesota Department of Transportation (MnDOT) found that the highway's existing HOV lane was underused while the general-purpose lanes were becoming increasingly congested

(Buckeye and Munnich 2006; Buckeye 2012). The study concluded that converting the HOV lane to a general-purpose lane would not be cost-effective and would ultimately increase congestion. Conversion to HOT lanes, on the other hand, would be both cost-effective and congestion-reducing.

In 2003, after nearly a decade of controversy, the Minnesota Legislature enacted HOT Lane legislation, which authorized the MnDOT commissioner to implement user fees on HOV lanes. As in other states, the legislation won support as a result of growing highway congestion and declining gas tax revenue. In 2005, MnDOT launched the MnPass project with the primary goals of 1) improving the efficiency of I-394 by increasing the carrying capacity of HOV lanes, in terms of both individuals and vehicles, and 2) maintaining free-flow speeds (45 mph) for transit and carpools in the express lanes (MnDOT 2005). Once opened, the new HOT lanes added 30 percent more trips to the previously underutilized HOV lanes.

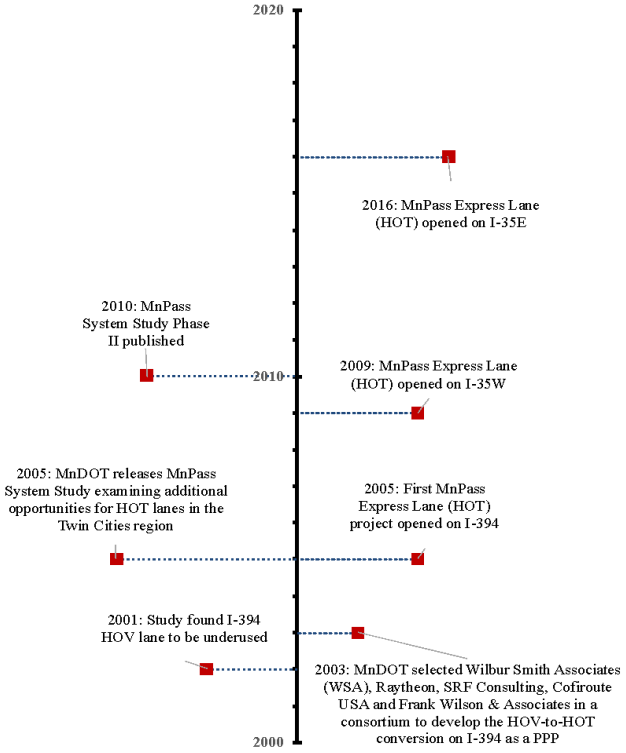

Figure 4: Minnesota's Initial Managed Lane Milestones

The 2003 legislation also directed MnDOT to prepare a MnPASS system study to examine the "impacts of overlaying a MnPass toll lane system in the Twin Cities metropolitan region of Minneapolis and St. Paul" with the primary objective of identifying a regional tolling system (MnPass System Study, 2005). In 2007, MnDOT was awarded $133.3 million for congestion management and transit projects from the USDOT as part of the Urban Partnership Program. Following the success of I-394 and the MnPass system study findings, MnDOT used a portion of this funding, which included $50 million in state-matched funding, to convert and construct HOT lanes on I-35W and I-35E (USDOT 2013; Buckeye 2014). These projects opened in 2009 and 2016, respectively.

A second phase of the MnPass system study was completed in 2010 and evaluated whether one could design and build a less expensive MnPASS system that still provided significant benefits. The result was a list of MnPASS expansion priorities, which was adopted into the Metropolitan Council's[8] 2040 Transportation Policy Plan (TPP) as the vision for the development of the MnPASS system (MnDOT 2010). Since the completion of the MnPASS System Study Phase 2, the MnPASS transportation system has expanded, and a Phase 3 study recently established a set of screening criteria for a new list of corridors for consideration in the 2040 TPP (MnDOT 2017).

[8] The Metropolitan Council (Met Council) is the metropolitan planning organization (MPO) for the Twin Cities region.

3.4 COLORADO

Like all states, Colorado's road infrastructure has been funded primarily by gas taxes, but Colorado residents had not voted to increase gas taxes since 1993. Colorado began considering toll-managed lanes in 2002 with the creation of the Colorado Tolling Enterprise (CTE), a division of the Colorado Department of Transportation (CDOT). Through CTE, the state sought to identify toll road opportunities in order to provide additional revenue to fund increased highway capacity and transportation infrastructure in the rapidly growing Denver area (CTE 2005). Specifically, the purpose of CTE was to "finance, construct, operate, regulate, and maintain a system of tolled highways in Colorado" (CDOT 2005).

In 2003, CTE initiated a statewide traffic and revenue feasibility analysis to identify potential toll projects based on financial feasibility. The analysis found that revenue from HOT lanes on I-25 near Denver would be able to fully fund the cost to convert the HOV lanes, as well as additional transportation improvements. The analysis also identified I-70, US-36, and C-470 as potential HOT corridors that would offer similar financial benefits (CTE 2004). As a result of this study, CDOT, along with CTE and local agencies, converted the I-25 HOV lanes to reversible HOT lanes, which opened in 2006. This first HOT lane project was developed and financed by the Colorado Department of Transportation (CDOT) using the traditional public sector design-bid-build model.

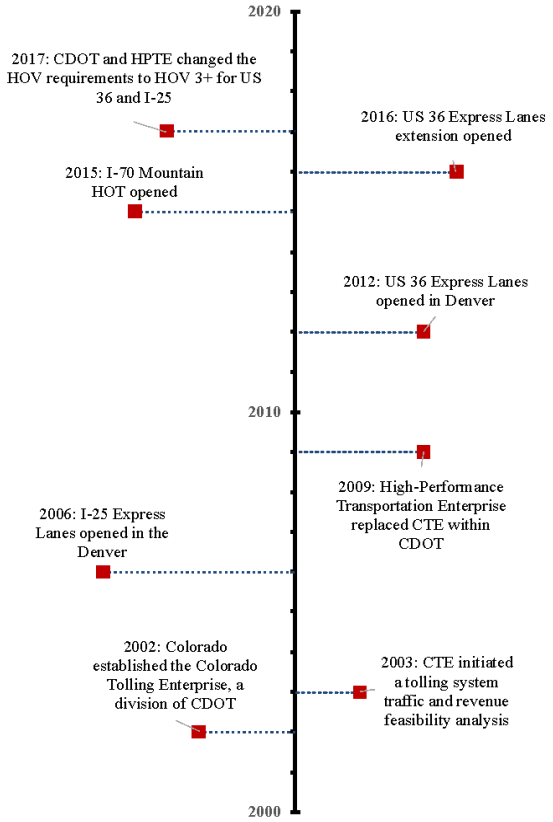

Figure 5: Colorado's Initial Managed Lane Milestones

In 2009, with gas tax revenue further on the decline due to inflation and the increasing use of fuel-efficient vehicles, the state of Colorado replaced the CTE with the High-Performance Transportation Enterprise (HPTE) through the state's Funding Advancements for Surface Transportation and Economic Recovery (FASTER) legislation. HPTE was tasked specifically to pursue public-private partnerships (PPPs) and other innovative financing mechanisms that could be used to more proactively address the state's growing congestion and capital improvements needs (CO Legislature 2009). HPTE was also created to help address Colorado's growing unemployment during the recession by providing jobs in construction through capital projects.

In 2012, with leadership from HPTE, CDOT opened its second HOT lane project in Denver on US-36 as a PPP. This project included building a new express lane in each direction and reconstructing the highway's existing pavement (Kenny 2013). Most recently, Colorado has used PPPs to open HOT lanes on I-70 and extend the US-36 HOT lanes. As of 2018, another

HOT lane project was under construction on C-470 and an additional project had been proposed for I-70 east (CDOT 2018).

3.5 CALIFORNIA

California has since built over 200 roadway miles of toll-managed lanes in the state's three largest metropolitan areas. The first project was built in response to southern California's rapid population growth, and resulting congestion levels, in the 1980s. Caltrans proposed constructing HOV lanes on the congested freeway, SR-91, which connected, at the time, to rapidly growing areas of Riverside and Orange Counties (Gómez-Ibáñez and Meyer 1993). The project was stalled, however, due to controversy over HOV lanes, and its funding was eventually redirected to other projects (Build America Bureau 2014).

In 1989, the California legislature enacted AB 680, which authorized Caltrans to enter into agreements with private entities for the construction of up to four highway demonstration projects throughout the state and required that at least one project be located in southern California and one project in northern California (CA Legislature 1989). The bill allowed private entities to identify, construct and charge tolls on privately constructed facilities. As a result, private investors organized the California Private Transportation Company (CPTC) which proposed to Caltrans to construct the planned SR-91 HOV lanes as express toll lanes under the new legislation. CPTC and Caltrans negotiated a build-transfer-operate franchise agreement for the project, which was awarded in December 1990. Construction of the new lanes began in 1993 and the new facility opened to traffic in December 1995 (Build America Bureau 2014). Following the success of SR-91, San Diego Association of Governments (SANDAG) converted HOV facilities on I-15 to HOT lanes in 1996, which became the second HOT lane project in the US.

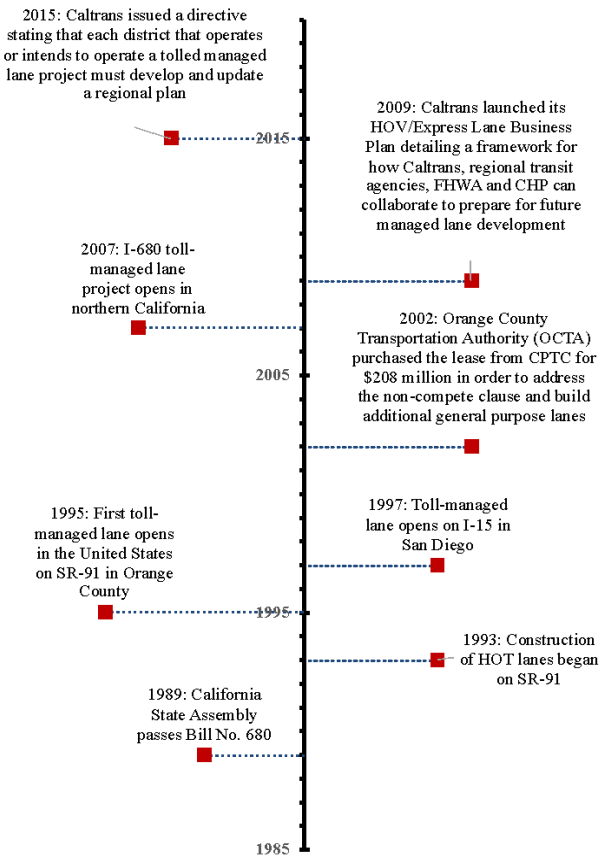

Figure 6: California's Initial Managed Lane Milestones

California's third HOT lane project was another of the projects selected under the AB 680 demonstration program, and the only selected project in northern California (Gómez-Ibáñez and Meyer 1993). This 85-mile HOT lane project, which opened in 2007, connects south San Francisco with south Sacramento along I-680 (Alameda County Transportation Commission 2013). Between 2005 and 2012, both SANDAG and Orange County Transportation Authority (OCTA) extended HOT facilities on both SR-91 and I-15.

With congestion continuing to increase throughout California's urban regions and with the overall success of HOT lanes, Caltrans adopted its HOV/Express Lane Business Plan in 2009, to provide local transportation agencies "the direction and flexibility needed to aggressively initiate innovative congestion management strategies." This plan, which was developed in collaboration with regional transit authorities, FHWA, and California Highway Patrol (CHP), outlined a framework for 2009 through 2011 to guide the development of HOV lanes and tolled managed lanes throughout the state. Specifically, the business plan provided direction, "on those aspects of HOV and express lane development and operations that can and should be addressed at a state level to increase California's ability to manage congestion with HOV and express lanes" (Caltrans 2009).

This business plan differed from the plans of other states, such as Minnesota and Colorado, in that it detailed a framework for providing regional agencies with the support and flexibility they needed to pursue congestion management projects and PPPs, rather than just a specific list of promising target conversion facilities. In May 2015, Caltrans issued a directive stating that all districts, along with their regional transit agencies, that currently operate or expect to operate toll-managed lane facilities must develop a Managed Lanes System Plan, which must be updated every two years. Of the five states discussed in this paper, only California requires its districts to prepare planning documents. As of 2014, Caltrans reported that there are 1,700 roadway miles of HOT lanes proposed or planned by both Caltrans and regional agencies (Rouse 2015). Additionally, in just the last few years, managed lanes have become operational on parts of SR 237 and I-880 in northern California as well as on the I-10 and I-110 in the Los Angeles County. As of 2017, there were also 50 miles of HOT lanes under construction (see Appendix A).[9]

4. DISCUSSION

4.1 TOLL MANAGED LANE MOTIVATION

These five states became early adopters of toll-managed lanes because of persistent congestion and significant budget shortfalls. Between 1990 and 2000 all five of these states experienced significant population increases. Indeed, this decade was the largest census-to-census increase in population in America's history. California had the largest population growth during this time period, followed by Texas. While Florida's population increased in tandem with the overall United States, the state is the fourth most populated state and is only preceded by California, New York, and Texas (US Census Bureau 2001).

These population characteristics resulted in the congestion challenges these states faced in the early 2000s and coincided with the introduction of the toll-managed lanes concept. Between 2000 and 2016, all of the case study states continued to experience population increases[10] and near or above average increases in total highway vehicle miles travelled (VMT). In this same period, three of the five states saw near or above average increases in VMT per capita (see Figure 7). This growth translates into more drivers driving more vehicles on U.S. highways, thus increasing congestion.

[9] See Rouse (2015) for a more detailed list of all managed lanes projects happening in the state.

[10] Between 1990 and 2010, California experienced an 18.8 percent increase in population, Texas and Florida each experienced 30.1 percent increase, Colorado experienced 32.6 percent increase, and Minnesota experienced 19.3 percent increase (US Census Bureau 2001).

Naturally, these trends in population and VMT growth are reflected in the urban congestion data. For instance, California, Texas, Florida, and Colorado are still home to more than a third of America's 25 most congested cities (see, e.g. INRIX 2018). Unsurprisingly, cities in California (i.e. Los Angeles, San Francisco, San Diego), Texas (i.e. Dallas, Houston, and Austin), and Florida (i.e. Miami, Orlando, and Tampa) are all major regions for toll-managed lane development. The same can be said for Colorado (Denver) and Minnesota (Minneapolis).

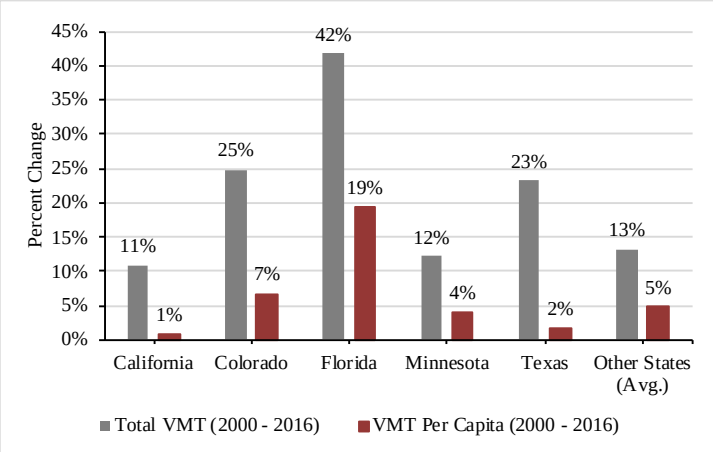

Figure 7: Change in Total VMT and VMT per Capita (Tax Policy Center 2018)

Stagnant gas tax rates in each of the pioneer states limited the ability of governments to collect enough revenue for transportation projects that would mitigate growing congestion. Between 2000 and 2009, none of the gas tax rates increased in any of the pioneer states (Tax Policy Center 2018). Even though revenue from gas taxes are the primary source of transportation funding, states have generally had difficulty increasing gas tax rates. This is not a partisan challenge either (see Figure 8). Democrat-leaning states (California, Minnesota), Republican-leaning (Texas, Florida), and "purple" states (Colorado) have experienced relatively similar gas tax rate trends (Pew Research Center 2014).

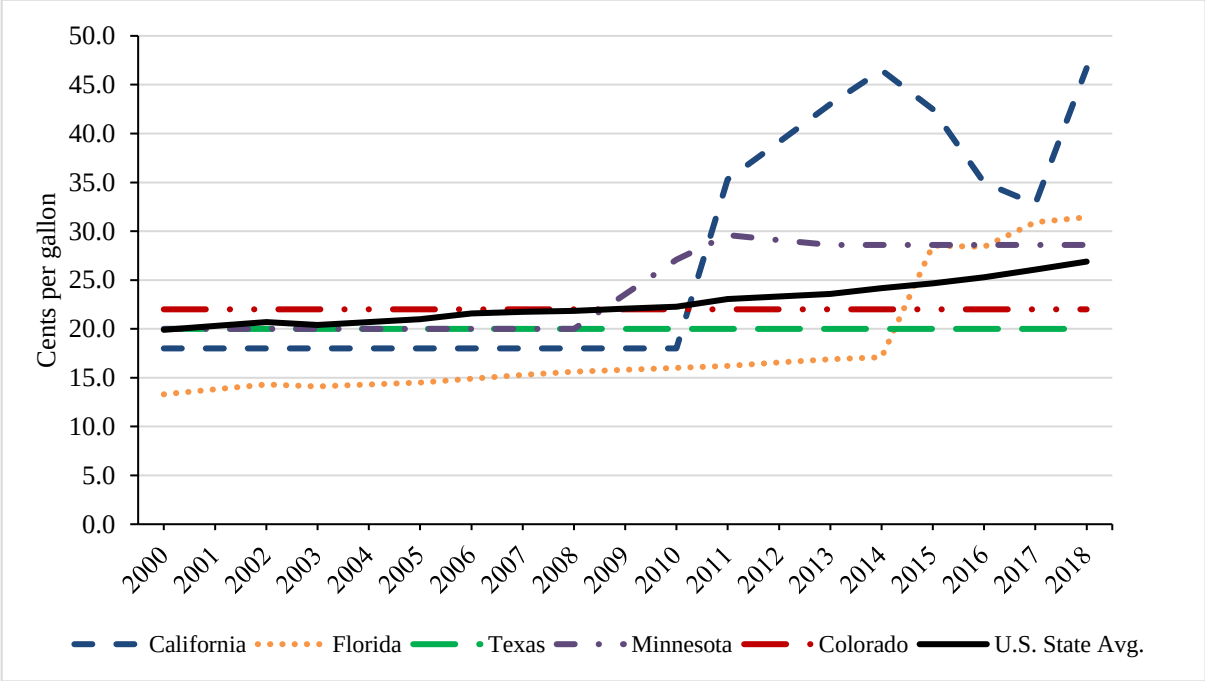

Figure 8: Gas Tax Rates in Each Pioneer State, 2000 – 2018 (Tax Policy Center 2018)

Stagnation of gas tax rates in each of these pioneer states offered further motivation for state governments to explore new, alternative financing methods for transportation projects. This delta between "need" and "ability" is evidenced by Florida's gas tax rate. Despite being one of

the fastest growing and most congested states, Florida's gas tax ranked between the 47th and 50th lowest rate in the United States in the early 2000s at 14 cents per gallon. In 2007, Florida began steadily increasing its gas tax rate and its current rate (31 cents per gallon) now hovers in middle of the state rankings. However, the delayed revenue gains from Florida's gas tax increases remain insufficient to cover the state's full array of transportation needs. This is just one reason why Florida has pursued toll managed lanes so aggressively.

Similar observations can be made for Colorado and Texas. Neither Colorado nor Texas have increased their state gas tax rates.[11] For Texas, this provides important context for the state's prolific use of toll managed lanes in Houston, Dallas, Ft. Worth, and now Austin to fund highway capacity projects and manage congestion. For Colorado, this also indicates toll managed lanes are being used primarily as a method for revenue generation, with secondary benefits coming from congestion relief. At the opposite end of the spectrum, California increased its state gas tax rate by 96 percent in 2011 from 18 cents per gallon to 35 cents per gallon. Since 2011, its rate has steadily increased and is now 48 cents per gallon, making it one of the highest tax rates in the country. Given the intensity of California's growth in the last two decades, this increase correlates to the state's burgeoning needs for transportation investments.

4.2 Toll Managed Lane Implementation

Although the nuances of toll-managed lane adoption differ slightly by state, the implementation process was similar. In all instances, the state transportation agencies conducted feasibility studies to determine which facilities were candidates for tolling and for toll-managed lanes specifically. However, these studies differ in size and scope. While Colorado conducted a statewide traffic and revenue feasibility analysis to identify potential toll projects, other states like Texas and California used corridor studies to identify congested routes within their large transportation networks. Additionally, both Florida and Colorado created new tolling "enterprises" within their state transportation agencies to lead the analysis and implementation of tolling projects. California had already gained experience with SR-91, but the other states implemented pilot toll-managed lane projects--including the Katy Freeway in Texas, I-95 in Florida, I-394 in Minnesota, and I-25 in Colorado—whose success spurred them to pursue additional projects (FHWA 2015).

However, the degree to which states have incorporated toll-managed lanes into their long-term transportation planning varies. Most of the five pioneer states are implementing toll-managed lane projects on a case-by-case basis. But some states, notably Florida and Minnesota, have drafted regional toll-managed lane studies to identify facilities best suited for these facilities; so far, however, few of the projects identified in these studies have been implemented (FDOT 2019 ;MDOT 2017. Although Colorado lacks a state-wide toll-managed lane agenda, it has systematically expanded its HOT lane facilities across the Denver region. California is unique in that the highways are primarily managed at the regional level by regional transportation agencies in conjunction with the state transportation agency. State legislation has enabled these regional agencies to pursue toll-managed lane projects, which all the large urban areas are doing. However, each regional agency is required to report its managed lane projects (either implemented or planned) to the state agency. Texas is similar to California in its use of regional transportation agencies to manage state highways and these agencies are able to pursue HOT lane projects. Unlike California, however, Texas does not have a state-wide reporting requirement. Further, each urban area in Texas – Dallas/Ft. Worth, Houston, and Austin – is financing and managing its toll-managed lane projects differently.

[11] The gas tax in Texas has not increased since 1991.

5. CONCLUSIONS

Overall, many transportation planners across the United States are starting to embrace toll-managed lanes as 1) an effective ADM technique to squeeze more capacity out of existing expressways and 2) as a politically palatable means of financing the construction of new highways in congested urban settings. As utilization of toll-managed lanes continues to grow, public officials will look to the early adopters of toll-managed lanes for guidance and insight. In this paper, we examined the adoption and utilization of toll-managed lanes in five pioneer states—Texas, Florida, Minnesota, Colorado, and California—in order to understand how these states embraced the toll-managed lane concept. While it is hazardous to broadly generalize about toll-managed lane adoption from only five US states, our case analysis is one of the first to highlight economic, political, and social factors motivating the adoption of toll-managed lanes. First, toll-managed lane utilization appears to be driven by a combination of factors, including rapid population growth, growing urban congestion, and insufficient gas tax funding for transportation investments. Second, toll-managed lanes adoption is generally predicated on the passage of state legislation as well as FHWA authorization to toll sections of the interstate system. Additionally, although the nuances of enabling legislation for toll-managed lanes differed between jurisdictions, the implementation process was generally similar across states. For example, in all instances, state transportation agencies conducted feasibility studies in order to determine which corridors were viable for toll-managed lane facilities. However, the size and scope of these studies differed from state to state. Finally, although these five states used similar means to instigate toll-managed lane utilization, the degree to which toll-managed lanes were integrated into the long-term transportation planning of each state varied wildly. This last result indicates that future work should give careful consideration to the transferability of toll-managed lane best practices across state lines. Moreover, more research is needed on the localized development of institutions enabling toll-managed lane adoption, utilization, coordination, and management.

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APPENDIX A: TOLL-MANAGED LANES THROUGHOUT THE US

U.S. TOLLED MANAGED LANE PROJECTS

NAME	STATE	REGION	FACILITY	STATUS	CONSTRUCTION TYPE	NEW FACILITY/ EXTENSION	YEAR OPENED	EXEMPTION	ORIGINAL OPERATOR	LENGTH (MILES)	INVESTMENT ($M)
SR 91 Express Lanes	CA	Orange County	SR-91	Operational	New Lane	New Facility	1995	HOV 3+	Private	10	$135
I-15 Express Lanes	CA	San Diego County	I-15	Operational	Conversion/New	New Facility	1996	HOV 2+	Public	20	$1,400
I-15 Express Lanes	CA	San Diego County	I-15	Operational	Conversion/New	Extension	2012	HOV 2+	Public	20	
MnPass Express Lanes	MN	Minneapolis	I-394	Operational	Conversion	New Facility	2005	HOV 2+	Public	22	$10
I-25 HOV Exppress Lanes	CO	Denver	I-25	Operational	New Lane	New Facility	2006	HOV 2+	Public	7	$9
Katy Managed Lanes	TX	Harris County	I-10/US 59/US 290	Operational	Conversion/New	New Facility	2009	HOV 2+	Public	12	$266
SR-167 HOT Lanes	WA	Seattle	SR-167	Operational	Conversion	New Facility	2008	HOV 2+	Public	9	$18
95 Express	FL	Miami-Dade, Broward, Palm Beach Counties	I-95	Operational	Conversion/New	New Facility	2008	HOV 3+	Public		$132
95 Express	FL	Miami-Dade, Broward, Palm Beach Counties	I-95	Operational	Conversion/New	Extension	2010	HOV 3+	Public		
95 Express	FL	Miami-Dade, Broward, Palm Beach Counties	I-95	Operational	Conversion/New	Extension	2016	HOV 3+	Public	22	
MnPass Express Lanes	MN	Minneapolis	I-35W	Operational	Rebuild/Conversion/New	New Facility	2009	HOV 2+	Public	20	$66 / $37
I-680 Southbound Express Lanes	CA	Alameda County	I-680	Operational	Conversion	New Facility	2010	HOV 2+	Public	13.7	$26
I-15 Express Lanes	NV	Las Vegas	I-15	Operational	New Lane	New Facility	2010	HOV 2+	Public	20	
I-15 Express Lanes	UT	Salt Lake City	I-15	Operational	Rebuild/New	New Facility	2010	HOV 2+	Public		$16.40
I-15 Express Lanes	UT	Salt Lake City	I-15	Operational	Rebuild/New	Extension	2012	HOV 2+	Public		$16.40
I-15 Express Lanes	UT	Salt Lake City	I-15	Operational	Rebuild/New	Extension	2016	HOV 2+	Public	35	$16.40
I-85 Express Lanes	GA	Metro Atlanta	I-85	Operational	Conversion	New Facility	2011	HOV 3+	Public	15.5	$60
SR-237 / I-880 Express Lanes	CA	Santa Clara County	SR 237 / I-880	Operational	Conversion	New Facility	2012	HOV 2+	Public		$5.60
I-110 MetroExpress Lanes	CA	Los Angeles County	I-110	Operational	Conversion	New Facility	2012	HOV 2+	Public	10.8	
Metro HOT Lanes (IH 45 South Gulf)	TX	Harris County	I-45	Operational	Conversion	New Facility	2012	HOV 2+	Public	15.5	
Metro HOT Lanes (IH 45 North Freeway)	TX	Harris County	I-45	Operational	Conversion	Extension	2012	HOV 2+	Public	20.6	
Metro HOT Lanes	TX	Harris County	US 290	Operational	Conversion	New Facility	2012	HOV 2+	Public	14	
Metro HOT Lanes (Southwest Freeway)	TX	Harris County	US 59	Operational	Conversion	Extension	2012	HOV 2+	Public	23.3	
495 Express Lanes	VA	Northern	I-495	Operational	Rebuild/New	New Facility	2012	HOV 3+	Private	14	$2,006
US 36 Express Lanes	CO	Denver	US 36	Operational	Rebuild/New	New Facility	2012	HOV 2+	Public		$497
US 36 Express Lanes	CO	Denver	US 36	Operational	Rebuild/New	Extension	2016	HOV 2+	Public	18	
I-10 Metro ExpressLanes	CA	Los Angeles County	I-10	Operational	Conversion	New Facility	2013	HOV 2+	Public	14.2	$79
595 Express	FL	Broward	I-595	Operational	New Lane	New Facility	2014	ETL	Public		
I-95 Express Toll Lanes	MD	Baltimore	I-95	Operational	Rebuild/New	New Facility	2014	ETL	Public	7	$103
NTE TEXPress Lanes	TX	Tarrant County	I-820	Operational	New Lane	New Facility	2014	HOV 2+ disc	Private	13.1	$2,100
Metro HOT Lanes (North Eastex Freeway)	TX	Harris County	US 59	Operational	Conversion	New Facility	2014	HOV 2+	Public	20	
95 Express Lanes	VA	Northern	I-95	Operational	Rebuild/New	New Facility	2014	HOV 3+	Private		
I-70 Mountain	CO	Denver	I-70	Operational	Conversion	New Facility	2015	ETL	Public	13	
LBJ TEXPress Lanes	TX	Dallas County	I-635/I-35E	Operational	New Lane	New Facility	2015	HOV 2+ disc	Private	13.3	$2,600
DFW Conntector TEXPress Lanes	TX	Dallas County	SH 114/SH 121	Operational	New/Rebuild	New Facility	2015	HOV 2+ disc	Public	4	
MnPass Express Lanes	MN	Minneapolis	I-35E	Operational	Conversion/New	Extension	2016	HOV 2+	Public		
I-580 Express Lanes	CA	Tri-Valley Corridor	I-580	Operational	Conversion	New Facility	2016	HOV 2+3+	Public		
I-30 TEXPress Lanes	TX	Dallas County	I-30	Operational	New Lane	New Facility	2016	HOV 2+ disc	Private	9	
I-405 Express Toll Lanes	WA	Seattle	I-405	Operational	Rebuild/New	New Facility	2016	HOV 3+	Public	17	
I-580 Express Lanes Project	CA	San Diego County	I-580	Operational	New Lane	New Facility	2016	HOT	Public	27	
I-680 SB and NB Express Lanes: Walnut Creek to San Ramon	CA	Contra Costa County	I-680	Operational	Conversion	Conversion	2017	HOT	Public	22.5	
MoPac Express	TX	Austin	Loop 1	Operational	New Lane	New Facility	2017	ETL	Public	11	$233
91 Project Fast Forward	CA	Riverside County	SR-91	Operational	New Lane	Extension	2017	HOT	Public		$1,400
I-75 South Metro Express Lanes	GA	Metro Atlanta	I-75	Operational	New Lane	New Facility	2018	ETL	Public	12	
35Express TEXPress Lanes	TX	Dallas County	I-35E	Operational	New Lane	Extension	2017	ETL	Private	30	
Northwest Corridor Express Lanes	GA	Metro Atlanta	I-75	Operational	New Lane	Extension	2018	ETL	Public	29.7	
NTE TEXPress Lanes	TX	Tarrant County	I-35W	Operational	New Lane	Extension	2018	HOV 2+ disc	Private	10.1	
Midtown TEXPress Lanes	TX	Dallas County	SH 183/114	Operational	New/Rebuild	New Facility	2018	HOV 2+ disc	Private	26.7	
I-30 TEXPress Lanes	TX	Dallas County	I-30	Operational	New Lane	Extension	2017	HOV 2+ disc	Private	12	
I-85 Extension	GA	Metro Atlanta	I-85	Operational	Conversion	Extension	2018	HOV 3+	Public	20	
I-580 Express Lanes: Tracy & Livermore	CA	Tri-Valley Corridor	I-580	Proposed	New Lane	Extension	2030	HOT	Public	16.8	
I-680 Express Lanes: Between Fairfield and Benicia	CA	Solano County	I-680	Proposed	New Lane	Extension	2030	HOT	Public	20.2	
I-15 Corridor Project	CA	San Bernardino County	I-15	Proposed	New Lane	Extension	2024	HOT	Public	33	
Northeast Florida Express Lanes	FL	Northeast Florida	I-95	Proposed	New Lane	Extension	N/A	ETL	Public	26	
Tampa Bay Next	FL	Tampa	I-75/I-275/I-4	Proposed	New Lane	New Facility	N/A	ETL	Public		
Georgia 400 Express Lanes	GA	Metro Atlanta	GA 400	Proposed	New Lane	New Facility	2024	HOT	Public		
I-55 Managed Lane Project	IL	Chicago	I-55	Proposed	New Lane	New Facility	N/A	HOT	Private		
Route 3 Express Toll Lane	MA	N/A	Route 3	Proposed	New Lane	New Facility	N/A	ETL	Private	17	
Northeast Florida Express Lanes	FL	Northeast Florida	I-295	Proposed	New Lane	Extension	N/A	ETL	Public	9	
635 East HOV/Express Lanes	TX	Dallas County	I-635	Proposed	New Lane	Extension	N/A	HOT	Private	9.3	
I-285 Eastside	GA	Metro Atlanta	I-285	Proposed	New Lane	New Facility	2025		Public		
I-285 Westside	GA	Metro Atlanta	I-285	Proposed	New Lane	New Facility	2026		Public		
I-285 Top End	GA	Metro Atlanta	I-285	Proposed	New Lane	New Facility	2028		Public		
I- 405 Express Lanes: SR 73 to I-605	CA	Orange County	I-405	Under Construction	Rebuild/New	New Facility	2023	HOT	Public	16	
I-680 Northbound HOV/Express Lane Project	CA	Alameda County	I-680	Under Construction	New Lane	Extension	2020	HOT	Public	13.7	
I-485 Express Lanes	NC	Charlotte	I-485	Under Construction	New Lane	New Facility	2022	HOT	Public	17	
I-880 Northbound/Southbound Express Lanes	CA	Alameda County	I-880	Under Construction	Conversion	New Facility	2020	HOT	Public	21	
I-15 Express Lanes	CA	Riverside County	I-15/SR-60	Under Construction	New Lane	Extension	2020	HOV 3+	Public	14.6	$425-450
US 101 Express Lanes/Silicon Valley Express Lanes	CA	Santa Clara County	US-101	Under Construction	Conversion/New	New Facility	2021	HOT	Public	36	
SR 85 Express Lanes/Silicon Valley Express Lanes	CA	Santa Clara County	SR-85	Under Construction	Conversion/New	New Facility	2021	HOT	Public	24	
I-80 Express Lanes: Emeryville to Fairfield	CA	Alameda County	I-80	Under Construction	Conversion/New	Extension	2021	HOT	Public	51	$76
I-80 Express Lanes: Vacaville to Davis	CA	Solano County	I-80	Under Construction	New Lane	Extension	2035	HOT	Public	32.7	
I-80 Express Lanes: Fairfield to Vacaville	CA	Solano County	I-80	Under Construction	Conversion/New	Extension	2021	HOT	Public	34	
I-680 SB and NB Express Lanes: Benicia to Walnut Creek	CA	Contra Costa County	I-680	Under Construction	Conversion	Extension	2021	HOT	Public	11	
I-10 Corridor Project	CA	San Bernardino County	I-10	Under Construction	New Lane	Extension	2023	HOT	Public	33	$672
I-70 East	CO	Denver	I-70	Under Construction	Rebuild	Extension	2022	ETL	Public	10	$1,200
Northeast Florida Express Lanes	FL	Northeast Florida	I-295	Under Construction	New Lane	New Facility	2019	ETL	Public	10	
I-66	VA	Beltway	I-66	Under Construction	Conversion/New	New Facility	2022	HOT	Private	22	$2,300
Palmetto Express	FL	Miami Dade, Broward Counties	SR-826/I-75	Under Construction	New Lane	New Facility	2019	ETL	Public	13	
I-77 Express Lanes	NC	Charlotte	I-77	Under Construction	Conversion/New	New Facility	2019	HOT	Public	26	$647
I-75 Express Lanes Project	FL	Miam-Dade County	I-75	Under Construction	New Lane	Extension	2019	ETL	Public	15	$485
I-30 TEXPress Lanes (West)	TX	Dallas County	I-30	Under Construction	New Lane	Extension	2020	HOV 2+ disc	Private	9.7	
I-805 Express Lanes Project	CA	San Diego County	I-805	Under Construction	New/Rebuild	New Facility	2020	HOT	Public	28	$1,100
C-470	CO	Denver	C-470	Under Construction	New Lane	New Facility	2019	HOV 2+	Public	12.5	$246
I-4 Ultimate	FL	Central Florida	I-4	Under Construction	Rebuild	New Facility	2021	ETL	Public	21	$2,300
SR-237 Phasse 2	CA	Santa Clara County	SR 237	Under Construction	Conversion	Extension	2019	HOV 2+	Public		

Sources: FHWA (2017); DOT websites