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# The Effect of Bus Lane Management Techniques on Operator Experience, Safety, and On-time Performance

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Client: LA Metro

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<b>16. Abstract</b> <p>Bus-only lanes can speed up buses and improve reliability of service. In Los Angeles County, there are 27 miles of mixed-use bus lanes. These lanes are passively enforced through striping and signage but do not receive regular active enforcement. Due to this lack of active enforcement, most of the lanes in LA County have high vehicle intrusion rates. I analyze two bus lanes that have received vastly different enforcement practices to conduct a comparative case study of the effect of enforcement on bus lane operations. I examine the following question: how do different management strategies for bus-only lanes, entailing design solutions, passive enforcement and active enforcement affect the safety, security and on-time performance of LA Metro bus operations? I rely on four main data sources from LA Metro to conduct these case studies: internal reports on bus lane enforcement costs and practices, bus operator surveys I administered jointly with LA Metro, in-service on-time performance data, and incident reporting of roadway collisions of Metro buses. I find that bus lanes in Los Angeles largely improve roadway safety and bus performance, and even more so when there are robust management practices in place. This research report fills a critical gap in the literature by documenting and quantifying the effect of unenforced lanes on the safety of bus operations.</p>			
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## Disclaimer

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# The Effect of Bus Lane Management Techniques on Operator Experience, Safety, and On-Time Performance

UCLA Institute of Transportation Studies

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# Executive Summary

## E1. Content and Background

### *Falling Ridership and a Re-Emphasis on the Bus*

Buses are the workhorse of many public transportation systems, accounting for around 4.5 billion transit trips per year in the US (National Transit Database, 2018). Yet, bus service has been largely overlooked and underfunded due to a national focus on building and financing heavy and light rail service. However, in the past decade declining transit patronage, primarily bus ridership, has encouraged transit planners to reemphasize the bus through increasing service and instituting bus priority measures. Redesigning bus systems, through improving routing, enhancing frequency of service, and building priority infrastructure, such as Bus Rapid Transit, has become very popular as planners and policymakers seek to win back transit riders (Higashide, 2019).

Although there are many ways to improve bus service, the core issues that bus riders care about are frequency and reliability of service. Frequency of service creates short wait times, and reliability increases riders' confidence that the bus will be on time ("Who's on Board," 2019). Transit agencies can increase frequency by adding the amount of service on a bus route. However, this alone does not translate into more reliable service. Congested streets result in bus bunching, or the uneven distribution of buses, that can increase wait times for passengers (Fleck, 2019).

Many cities are designating specific areas where the bus can bypass traffic through installing bus-only lanes, dedicated lanes where buses have exclusive or semi-exclusive rights of way (Agrawal et al., 2013). Bus-only lanes can often work in tandem with other priority measures that are in combination effective strategies to speed up buses and improve headway adherence, or the reliability of service based on consistent wait times for passengers ("Bus Priority Treatment Guidelines," 2011). However, bus lanes introduce new challenges. Blockages in the bus lane, most commonly caused by vehicle intrusions—where vehicles not authorized to drive or park in the bus lane do so—cause challenges for bus operators and delays in service (Agrawal et al., 2013). When asked, bus operators have indicated that bus lanes, when clogged with private vehicles, can make driving the bus more difficult because lane blockages force operators to constantly weave in and out of traffic ("Wilshire BRT Project: Before and After Report," 2017).

A bus lane's design largely informs the types of management that is required to keep the lane clear (Agrawal et al., 2013). A busway, in comparison, provides a dedicated right of way for buses that is completely separated from traffic, which reduces conflicts with motorists ("Transit Capacity and Quality of Service Manual", 2013). Busways are easier to enforce due to strict separation of buses and unrestricted lanes of traffic. However, semi-exclusive or mixed-use bus lanes can be easier to implement as they only require the

conversion of one or two curb lanes for buses, and allow for certain users to share the lane, such as bicyclists and right-turning motorists (Agrawal et al., 2013). However, these types of lanes are more prone to traffic intrusion and conflicts. As mixed-use bus lanes are located alongside general use traffic lanes, such as when repurposed curbside parking lanes or in median lanes have been reconfigured for a bus lane, other road users are more likely to use the lane (either legally or illegally). For example, most mixed-use lanes allow bicycles and right turning vehicles. Although this is a legal use of the lane, it causes delay for operators. Most conflicts, however, come from illegal lane users, such as private vehicles driving or stopping in the lane. In order to reduce illegal vehicle intrusions in mixed-use bus lanes, planners often use various bus lane management techniques, including design strategies, as well as passive and active enforcement (Agrawal et al., 2013).

Design strategies include configuring the bus lane away from the curb, so that it is offset from parking and loading zones, as well as restriping the street to allow for a median-running bus lane, often with median islands to allow for passengers to safely board and alight the bus (“Bus Priority Treatment Guidelines,” 2011; “Transit Street Design Guide,” 2016). Passive enforcement techniques include installing regulatory signs and striping to alert private vehicle drivers to stay out of the bus lane (often with posted violation fines), as well as painting the bus lane red, a technique growing in popularity. Active enforcement is the use of boots-on-ground enforcement, such as a dedicated police or parking unit for bus lane enforcement, that enforce moving and/or parking violations. Active enforcement also includes the towing of parked vehicles in highly-visible “enforcement blitzes.” Additionally, some cities rely on automated enforcement techniques, such as cameras installed in the bus lane that can detect violations, read license plates, and issue motorist violations by mail (Agrawal et al., 2013).

## E2. Project Context and Justification

### *Speeding up LA Metro’s buses*

Buses carry 70 percent of LA Metro customers in Los Angeles County, or nearly 900,000 a day (“Interactive Estimated Ridership Stats,” n.d.).<sup>1</sup> Congestion greatly effects the efficiency and reliability of LA Metro’s bus system, resulting in a 12.5 percent drop in average bus speeds over the last 25 years (Nelson, 2019). Mixed-use bus lanes give buses the opportunity to bypass traffic, which can improve reliability and travel speeds.

In Los Angeles County, there are 27 miles of mixed-use bus lanes. These lanes are passively enforced through striping and signage but do not receive regular active enforcement. Due to this lack of active enforcement, most of the lanes in LA County have high vehicle intrusion rates. A particularly notorious location for vehicle intrusions is a mixed-use bus lane on Wilshire Boulevard, which was fully installed in 2015 and is not actively

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<sup>1</sup> Prior to the 2020 COVID-19 pandemic, based on 2019 weekday estimated ridership levels. Ridership is measured in unlinked transit trips. See more at: <http://isotp.metro.net/MetroRidership/Index.aspx>

enforced by police (S. Walker, personal communication, July 18, 2019).<sup>2</sup> A preliminary study of Wilshire Boulevard found that lane intrusions occurred at a rate of one every four minutes during the bus lane operating hours (Shavit, 2019).

In 2019, the Los Angeles County Metropolitan Transportation Authority (LA Metro), in partnership with LADOT, piloted a bus lane in Downtown Los Angeles on Flower Street that received dedicated police enforcement (“New Blue Improvements Project,” n.d.). The pilot was largely successful due to this enforcement; it sets a new model for how bus lanes in Los Angeles should be managed in order to maximize potential time savings, increase operational efficiency, and reduce vehicle-to-vehicle conflicts.<sup>3</sup>

For this report, I analyze these two bus lanes, which have received vastly different enforcement practices. I conduct a comparative case study of the effect of enforcement on bus lane operations to examine the following question: *How do different management strategies for bus-only lanes, entailing design solutions, passive enforcement, and active enforcement, affect the safety, security and on-time performance of LA Metro’s bus operations?*

I rely on four main data sources from LA Metro to conduct these case studies:

- personal communication with LA Metro and LAPD staff and review of internal reports on bus lane enforcement costs and practices,
- bus operator surveys I administer jointly with LA Metro,
- incident reporting of roadway collisions of Metro buses, and,
- in-service on-time performance data.

LA Metro has committed to constructing three bus rapid transit projects in the next ten years, which will include an addition of approximately 75 lane miles<sup>4</sup> of mixed-use bus-only lanes (“Twenty-Eight by ’28 Initiative,” n.d.). As LA Metro, and other transit agencies across the US, continue to plan and invest in bus lanes, it is important to measure the impact of these investments and how to deploy and manage these lanes most effectively. Bus lanes are increasingly a tool that US cities are implementing, and a few of these cities have developed a comprehensive enforcement policy for these lanes (Agrawal et al., 2013). Until better management practices are instituted system wide, the issue of motorist violations will most likely only get worse as LA Metro grows its bus lane network.

This research report fills a critical gap in the literature by documenting and quantifying the effect of unenforced lanes on the safety of bus operations. The findings on the effect of bus

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<sup>2</sup> See an example of media coverage of bus lane violations on Wilshire Boulevard in Damien Newton’s article in Streetsblog LA, entitled “Eyes on the Street: Wilshire’s Car-Only Bus Lane.” <https://la.streetsblog.org/2018/11/19/eyes-on-the-street-wilshires-car-only-bus-lane/>

<sup>3</sup> See forthcoming research by E. Huang E. and C. Halls entitled “Case Study on LA Metro’s Flower Street Bus-Only Lane”

<sup>4</sup> Calculation by the author, based on published alternative analyses and route maps.

lanes on on-time performance supplement existing literature focused on speed, load capacity, and reliability improvements.

## E3. Findings

Bus lanes provide enormous benefit for transit agencies and bus operators and improve travel speeds, reliability, and can reduce the likelihood of certain types of collisions. Bus operators largely agree that bus lanes allow for greater service reliability and travel speeds, even more so when they are enforced. Mixed-use bus lanes, which are largely used in the US and in congested urban cores, are also prone to motorist violations and other types of conflicts. As mixed-use bus lanes are used more extensively (both nationally and in LA County context, specifically) it is important to ensure that these assets are properly designed and managed to ensure the best outcomes.

### *Key Findings*

My findings fall under four broad sections:

- bus lane management practices,
- bus operator experience,
- collision incidence, and lastly,
- on-time performance.

Eight key findings are listed below:

#### Bus Lane Management Practices

#### **Finding 1. Existing passive enforcement techniques and design solutions are not sufficient for managing mixed-use bus lanes in Los Angeles.**

The Wilshire Boulevard bus lane is primarily managed through passive enforcement techniques as well as limited active enforcement through transit vehicle patrol. The Los Angeles Police Department (LAPD) is contracted by LA Metro to provide transit vehicle patrol, which is primarily focused on the safety and security of bus operators and passengers, not keeping the bus lane clear. The current enforcement practices on the Wilshire Boulevard bus lane are not sufficient to maintain a well-functioning bus lane. LA Metro found that on average violations occurred every four minutes on the bus lane (Shavit, 2019).<sup>5</sup> By not paying for enforcement up front, LA Metro is indirectly paying for it through reduced operational efficiency and on-time performance.

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<sup>5</sup> During its operating hours, or from 7-9 am and 4-6 pm. This research was conducted through a free proof of concept with Carma Cam, a dash camera application that can allow bus operators to touch the screen to record a violation. This was deployed on a few buses during the study period, and operators were trained how to use the software. For more information, see LA Metro's 2019 Innovation Portfolio at: [http://media.metro.net/about\\_us/oei/images/unsolicited\\_proposal\\_policy\\_2019.pdf](http://media.metro.net/about_us/oei/images/unsolicited_proposal_policy_2019.pdf)

There have been multiple points in the Wilshire bus lane's history when enforcement was recommended with clear empirical evidence for its benefit (City Council File 03-2337-S1, 2007; "Wilshire BRT: Before and After Report," 2017). There have also been signs that the curbside configuration of the bus lane was not ideal for traffic conditions in congested segments of the bus corridor ("Wilshire BRT: Before and After Report," 2017). However, neither of these management strategies were implemented. The experience on Wilshire Boulevard shows that existing management practices are not sufficient, and do not allow for the benefits of bus lanes to be fully realized. Current management practices on the Wilshire bus lane do not allow for the performance benefits of the bus lane to be fully realized, as evidenced in subsequent findings.

**Finding 2. Dedicated bus lane enforcement is effective but expensive. To create a scalable option, Metro would have to automate enforcement on bus lanes.**

LA Metro took a relatively new approach to bus lane enforcement on the Flower Street bus lane pilot project, a temporary bus lane that was deployed during a major state-of-good repair project in Downtown Los Angeles ("New Blue Improvements Project," n.d.). The bus lane was used in a heavily trafficked corridor that necessitated active enforcement to keep buses moving.<sup>6</sup> LA Metro relied on a dedicated unit of LAPD officers to keep the bus lane clear. Although highly effective, this enforcement strategy cost upwards of \$26,000 a weekday to deploy on 6.4 lane miles.<sup>7</sup>

Based on a back-of-the-envelope calculation, if such a system were deployed systemwide, it would cost LA Metro \$37.9 million a year to have similar level of enforcement across its 27 miles of mixed-use bus lanes in Los Angeles County.<sup>89</sup> Research suggests that it would be a much more efficient, effective, and equitable strategy to automate enforcement (Gordon, 2020; "Bus Lane Enforcement Study," 2017; "San Francisco TOLE Final Report," 2015).

#### Operator Experience

**Finding 3. Even when unenforced, bus lanes provide a benefit. However, enforcement is tied to positive outcomes for the bus lane.**

I deployed surveys to bus operators on the Flower Street and Wilshire Boulevard bus lanes to determine how operators perceived the bus lanes' effectiveness, and how conflicts in the lanes affect performance and safety outcomes. In line with existing literature, bus lanes, even when unenforced, provide some degree of benefit. However, these benefits are maximized with active enforcement. Operators on the Flower Street bus lane reported

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<sup>6</sup> Included Express, Select and Local bus bridge service to substitute for the out of commission rail line.

<sup>7</sup> Police simultaneously enforced the Flower Street bus lane, a total of 1.8 lane miles, along with the Figueroa Boulevard bus lane, a total of 4.6 lane miles. The Figueroa Blvd bus lane was also enforced as it was used for northbound buses traveling between the closed rail stations in Downtown LA. Flower Street is a one-way street that was only used for southbound buses.

<sup>8</sup> For details on this estimate, see **Table 2:** Comparison of bus lane active enforcement costs, in the Section entitled "Bus Lane Management Practices" in the Findings Section.

<sup>9</sup> Based on total lane miles.

greater reliability of service and travel time savings compared to Wilshire Boulevard bus operators.

**Finding 4. Conflicts in the bus lane are similar across unenforced and enforced bus lanes, and the greatest amount of delay is due primarily to parked private cars, Uber/Lyft or taxis idling in the lane, and private vehicles illegally driving in the lane.**

Surveyed bus operators were asked what conflicts most affect their ability to use the Flower Street or Wilshire Boulevard bus lane. The most common answer for both the Flower Street and Wilshire Boulevard was parked vehicles (approximately one-quarter of all operators), followed by motorists illegally driving in the lane, and Uber/Lyft vehicles and taxis stopped in the bus lane. Although the types of conflicts are similar across lanes, the amount of disruption they cause diverge greatly:

- Wilshire bus lane: a larger share (84%) of surveyed bus operators stated that the five most common vehicle intrusions were always causing delay.
- Flower Street bus lane: a lower share (53%) of surveyed bus operators stated that these conflicts were always causing delay.

This lower proportion of delays on Flower Street is most likely due to presence of active enforcement there.

**Finding 5. Operators view certain intersections as hot spots of vehicle intrusions.**

Bus operators were also asked if there were certain segments or intersections where bus lane violations occurred the most. For each bus lane, certain intersections were called out as hotspots of violations; on Wilshire Boulevard it was the intersections with Vermont Avenue, Western Avenue, and Normandie Avenue. On the Flower Street bus lane, operators cited intersections with Pico Boulevard, Olympic Boulevard and 7<sup>th</sup> Street as sites of rampant violations. This suggests that although vehicle intrusions can occur along the whole bus lane, they are also highly localized: there are certain parts of the bus lane where violations are consistently delaying bus operators. Additionally, regular bus operator feedback such as this can help inform planning, design, and management processes of bus lanes.<sup>10</sup>

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<sup>10</sup> LA Metro commonly uses “Rap Sessions” that allows bus operators to report out issues from their line or route. This is used regularly and allows for a line of communication between bus operators, service planning staff, and law enforcement agencies. However, this report demonstrates the value of frequent operator surveys that provide for data-driven decision-making. For an example of how rap sessions inform planning, see a presentation on the NextGen Bus Study Transit Market and Travel Demand from June 2018, at: [http://media.metro.net/board/Items/2018/06\\_june/20180611sbaitem6.pdf](http://media.metro.net/board/Items/2018/06_june/20180611sbaitem6.pdf)

**Finding 6. Most operators perceive that vehicle intrusions reduce roadway safety, causing them to have to weave in and out of traffic, increasing their stress and the likelihood of collision.**

Bus operators largely perceive that bus lane violations reduced roadway safety, and operators on Wilshire Boulevard generally felt less safe compared to operators on the Flower Street bus lane.

- On Wilshire, 73 percent of operators strongly agree that bus lane intrusions cause them to weave in and out of traffic, and 68 percent strongly agree that this puts them at a higher risk of collision.
- On Flower, a lower share (60%) of operators strongly agree that bus lane intrusions cause them to weave in and out of traffic, and 52 percent strongly agree that this puts them at a higher risk of collision.

Operators also perceived, to a lesser extent, that bus lane violations increased their stress and reduced their on-time performance, and caused more passengers to be dissatisfied with bus service. Across all of these measures, the Wilshire Boulevard bus lane is lower-performing than Flower Street. Operators on Flower overall perceived greater safety and on-time performance as a result of fewer conflicts in the bus lane.

#### Collision Incidence

**Finding 7. Overall, traffic-related collisions have declined since the installation of the Wilshire Boulevard bus lane, but have not changed on Flower Street. Of all collision types, the only types that were significantly reduced with the introduction of the Wilshire Boulevard bus lane were from vehicles turning right into the bus.**

To understand how the presence of the bus lane affected bus collision incidence, I conducted before and after comparisons on both Flower Street and Wilshire Boulevard. I compared collision incidence one year before the Flower Street bus lane (June 2018 – January 2019), and during the pilot period of the bus lane (June 2019 – January 2020).<sup>11</sup> For Wilshire Boulevard, I compared four years before the installation of the bus lane, and four years after (I exclude 2015 as this was the year that the majority of the bus lane was installed). This decline in collisions is most likely related to the physical design of the bus lane, where the dedicated curbside lane reduces the likelihood of a vehicle merging into the bus from the right. This most likely reduces the chance of right-side collision incidence.

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<sup>11</sup> I used the following Metro lines for my analysis: Line 720, 20 (Wilshire Boulevard bus lane), Line 460, and the J Line (Flower Street bus lane).



## On-time Performance

### **Finding 8. The bus lanes have had mixed effects on on-time performance.**

On Wilshire Boulevard, on-time performance improved within bus lane segments for Eastbound service, but declined for Westbound service.<sup>12</sup> This was most likely due in part to construction for Phase I of the Purple Line Extension, a major rail extension project that affected the bus lane between Wilshire/Western and Wilshire/La Cienega.<sup>13</sup> Additionally, a lack of enforcement might have diluted the effect of the bus lane, due to frequent vehicle intrusions.

On Flower Street, there was a very slight improvement in on-time performance after the installation of the bus lane, although the time span of analysis does not produce enough data to draw conclusions with certainty. However, some research suggests that on-time performance is not the best measure of bus lane management practices because of the inefficient operational practices it produces (“Elevated Standards for Bus Operations –Scheduling and Dispatching,” 2019; “Transit Capacity and Quality of Service Manual,” 2013).

## **E4. Policy and Practice Implications**

Current bus lane management practices deployed by LA Metro are not allowing for on-time performance goals to be met. However, evidence from the Wilshire bus lane shows a positive correlation between the presence of the bus lane and increased roadway safety. Yet, based on operator surveys, this too could be improved with enforcement. Additionally, newer strategies, such as the deployment of a dedicated police unit on the Flower Street bus lane, are probably too costly and labor-intensive to be a sole strategy deployed system-wide. LA Metro could use its existing resources more strategically to produce better outcomes on all its mixed-use bus lanes.

LA Metro should consider developing a comprehensive enforcement strategy that accounts for the worst bus lane offenders and locational hotspots. This could include a suite of solutions, that are applied to different contexts.

Systemwide strategies include:

- Deploy lower-cost active enforcement across all of its mixed-use bus lanes, such as automated enforcement or intermittent, highly visible parking enforcement at the start of peak hours. This report finds that parked vehicles are the most common violation type, and cause the most delay, which could be targeted through such an approach.
- Ramp up existing passive enforcement techniques, such as increasing visibility of bus lane signage, and possibly painting bus lanes red. However, this would have to

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<sup>12</sup> Similar to my analysis of collision incidence, I include Line 720, 20, 460 and the J Line for on-time performance reporting.

<sup>13</sup> Now called the D Line. For more information on this project, see <https://www.metro.net/projects/westside/>

be deployed system-wide to reduce possible effects of reduced compliance on non-painted lanes.

Localized strategies include:

- Install different design solutions in heavily congested sections of bus corridors, such as offset lanes, to reduce the frequency of lane intrusions.
- Continue to deploy higher-cost, more resource-intensive dedicated police units in violation hotspots in heavily congested areas. However, this should be carefully considered and seen as a short-term solution (due to the opportunity for racial bias and high labor costs) to be replaced with automated enforcement when legal. For example, automated enforcement cameras could be installed on fixed posts at these intersections.
- Like the Flower street pilot, LA Metro could continue to deploy temporary bus lanes as a traffic mitigation strategy for major transit service disruptions. This would allow bus lane installation and management costs to be folded into Metro's capital infrastructure budgets like the New Blue Improvements Project (such as the Purple Line Extension).

At the time of writing this report, LA Metro is seeking enabling legislation to allow for automated camera technologies on bus lanes that streamline enforcement. However, this has been delayed until a later legislative session in 2020 (N. Borgman, personal communication, May 4, 2020). As seen in New York and San Francisco, an automated bus lane enforcement system can take years to pass and implement ("Transit-Only Lane Enforcement," n.d.; "Bus Lane Enforcement Study," 2017). Although obtaining legislative authority is difficult, this is a worthwhile endeavor. Other applications of automated enforcement technologies, such as red-light cameras and speed cameras, have proven to be effective at increasing safety while reducing incident and enforcement costs as well as risks and bias associated with active policing (Council et al., 2015; "Speed Enforcement Camera Systems Operational Guidelines," 2008).<sup>14</sup>

Early findings from other US cities with automated enforcement suggest that this approach would be lower cost than existing strategies deployed by LA Metro, and have a greater effect on changing behavior of motorists. Both San Francisco and New York City cite their automated bus lane enforcement systems as a key factor in increasing bus travel speeds, improving headway adherence, and changing motorist behavior ("Transit-Only Lane

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<sup>14</sup> Implicit bias is a major issue within police departments across the country. There is strong evidence of persistent racial bias in the LAPD/LASD, and notorious cases of police brutality against African American individuals, such as Rodney King, who was brutally beat by police officers, inciting large-scale civic discourse and the 1992 LA Riots. This is directly relevant to this study, as reporting conducted by the LA Times, for example, has shown that the LAPD searches black and Latino individuals more than white individuals. Having LAPD enforcement on bus lanes introduces opportunities for bias, which could be mostly addressed through automated camera enforcement. For more information on racial disparities of traffic stops, go to: <https://www.latimes.com/local/lanow/la-me-lapd-searches-20190605-story.html>

Enforcement,” n.d.; “MTA bus-mounted camera program begins issuing bus lane violations on B44 SBS route,” 2020).<sup>15</sup>

However, even if automated enforcement is legally approved, LA Metro should use it in tandem with other solutions, including boots-on-the-ground, design solutions, and passive enforcement techniques. LA Metro should develop a formalized bus lane management program, with a dedicated carve out of its existing enforcement budgets, and its capital program. Lastly, the agency should develop new metrics such as headway adherence for measuring the performance of the bus lane network, and evaluating the effectiveness of different management techniques.

## E5. Conclusion

The Flower Street and Wilshire Boulevard bus lanes demonstrate two schools of thought about bus priority infrastructure. Wilshire Boulevard exemplifies the US approach to Bus Rapid Transit (BRT) projects. High capital costs (\$31.5 million for the Wilshire BRT project), limited street redesign, and pedestrian improvements, such as improved bus stops and zones, are typical for these types of projects. The Flower Street bus lane represents a newer, opposite approach. This bus lane relies on a tactical approach, with quick-build temporary roadway modifications that are low-cost (\$75,000 for installation).

Each approach has its own benefits and challenges. However, regardless of a planner’s chosen strategy when designing and installing a bus lane, they are essentially part of a balancing act. Costs not paid upfront will be paid for through externalities, such as bus performance under targeted goals, minimal operational efficiency improvements, or, if enforcement is implemented, increased enforcement costs to keep the lane clear. Planners and policymakers should therefore push for a bus lane design that affords the highest “scope of priority” that is physically and politically possible (Agrawal et al., 2013). Planners should be considering lifecycle costs when scoping out, and budgeting for, a bus lane project.

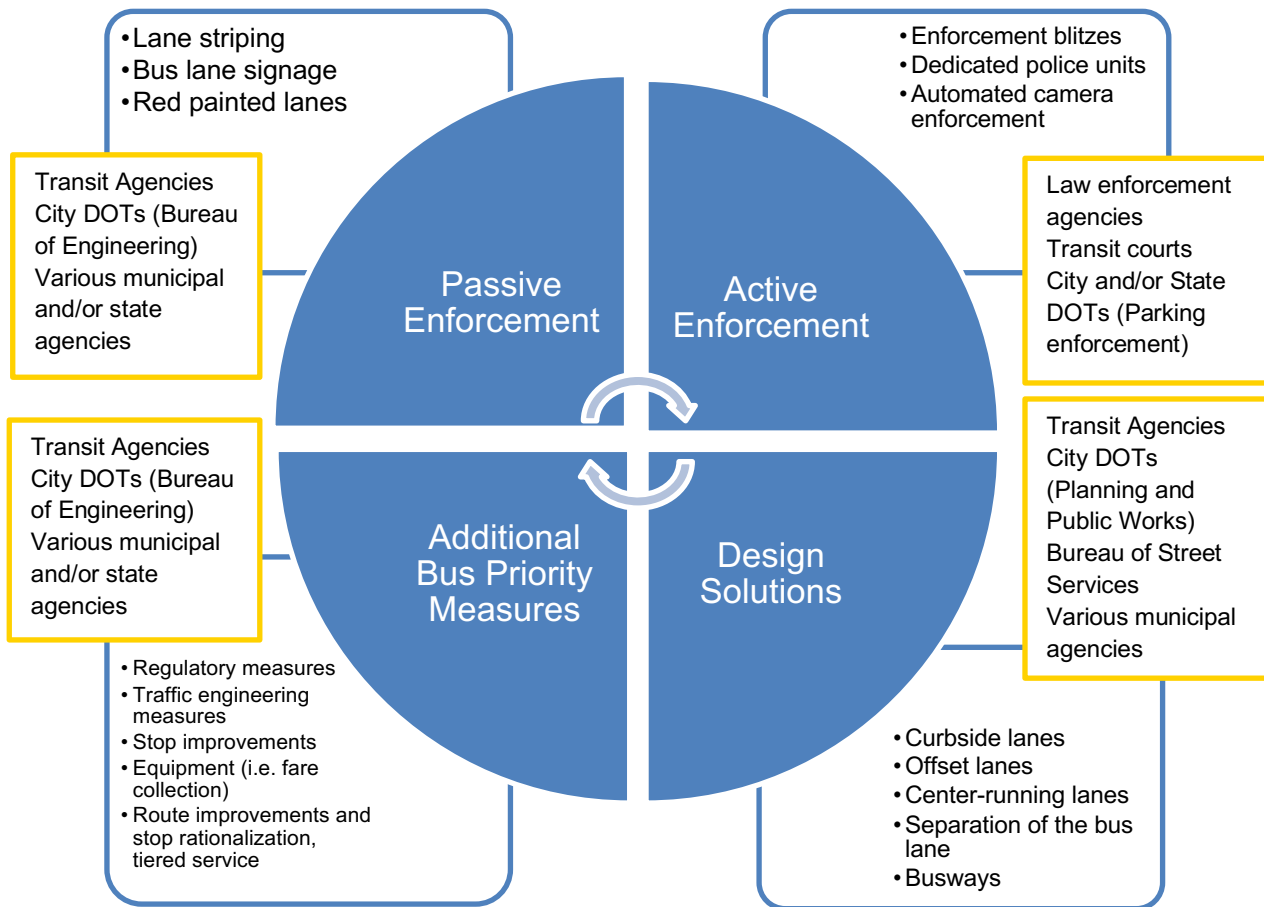
Bus lanes require more than pavement striping to be successful. Physical infrastructure needs to be matched with strong institutional arrangements. This report only lightly touched on the plethora of bus priority measures that can be instituted with bus lanes. However, these should be a part of an agency’s decision-making when developing a comprehensive bus lane management program (see **Figure 1**). Although standards and guidance exist, planners and policymakers have to determine the right combination of passive enforcement techniques, design solutions, priority infrastructure, and active enforcement strategies that will allow a bus lane project to be built and provide the greatest performance outcomes.

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<sup>15</sup> New York City MTA cited bus speed increases of 17 percent on segments of a route using automated cameras. An additional measure called the “wait assessment” which measures bus reliability was at 78.1 percent, more than 3 percent higher than the previous year. SFMTA reports reductions in delay as a result of the bus lane enforcement program, from 3 to 20 percent. Over a two-year timespan, the number of violations issued was cut in half, and repeat offenders only made up 1% of the total citations.

When developing a management program, agencies will have to formalize institutional partnerships between law enforcement, city governments, municipal agencies, and other key decision-makers. Transit agencies, departments of transportation, and law enforcement agencies might have different (or even opposite) operating practices and objectives that can make collaboration challenging. This report provides empirical data that can guide the development of shared language and goals around bus lane management practices that can hopefully help bridge this gap.

**Figure 1:** Proposed model for bus lane management system and institutional arrangements

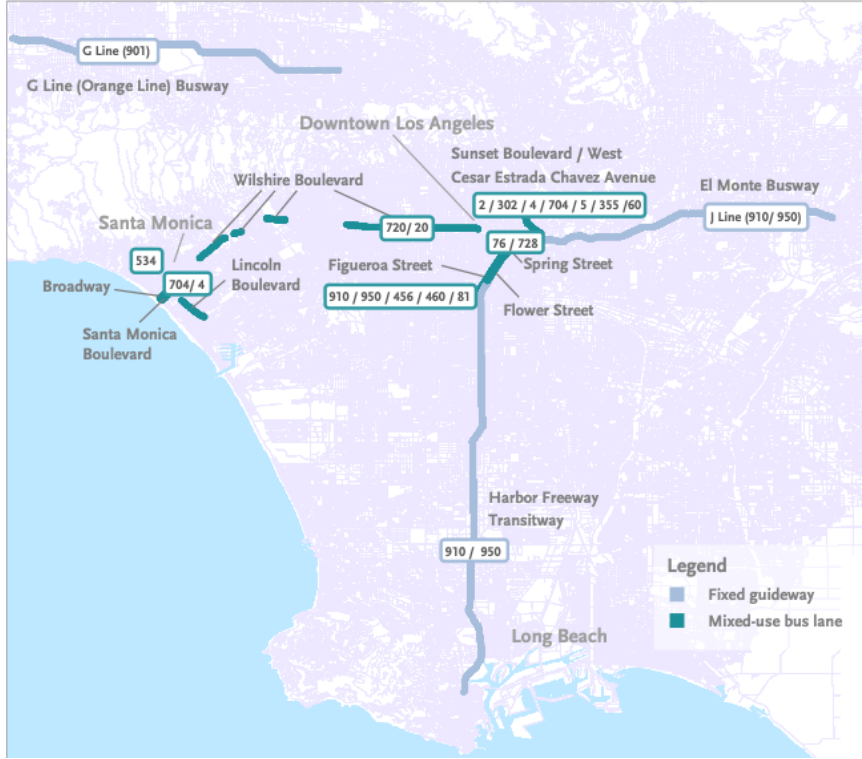


*Author-made figure based on research.*

# Introduction

Within Los Angeles County, worsening street traffic congestion has resulted in slow, unreliable, and infrequent bus service for nearly one million daily transit riders, as well as increasingly stressful driving conditions for bus operators. Bus-only lanes can allow transit vehicles to bypass congestion, but only if motorists do not park or drive in these lanes. There are two main categories of bus lanes in Los Angeles County: busways, which require a dedicated right of way for buses, and mixed-use bus only lanes, which are semi-exclusive and often utilize the curbside lane for the exclusive use of buses, bikes, and right-turning vehicles. There are approximately 107 lane miles of bus-only lanes in Los Angeles County, 27 of which are mixed-use bus only lanes. These existing bus-only lanes are detailed in Appendix A (See **Figure 2**).

**Figure 2:** Existing busways and mixed-use bus lanes in Los Angeles County



*Author-made figure based on own research*

Mixed-use bus lanes are more prone to motorist violations than busways, as the former are in a shared right of way. Bus operators have indicated that mixed-use bus lanes, when clogged with private vehicles, can make driving the bus more difficult than a clear bus lane. Blockages in the lane force operators to weave in and out of the mixed-use traffic lanes in order to avoid private vehicles in the bus lanes.

Accordingly, I seek to answer the following question in this study: *How do different management strategies for bus-only lanes, entailing design solutions, passive enforcement, and active*

*enforcement, affect the safety, security and on-time performance of the Los Angeles County Metropolitan Transportation Authority's (LA Metro) bus operations?*<sup>16</sup>

To quantify the effect of enforcement in mixed-use bus lanes on the on-time performance and the safety and security of bus operations, I analyze and compare two mixed-use bus-only lanes in Los Angeles on Flower Street and Wilshire Boulevard (See Figure 5). In doing so, I use a variety of approaches to examine how bus operator experience and enforcement practices differ for these two bus corridors between June 2019 and January 2020, including operator surveys, on-time performance data, and reporting of incidents and collisions.

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## **Overview of Research Methods**

I conduct a comparison of two bus lanes in Los Angeles, the Wilshire Boulevard and Flower Street bus-only lane. The research explores the following four dimensions of these case study bus lanes:

**Bus Lane Management Practices:** Management of bus lanes falls into three categories—design solutions, passive enforcement, and active enforcement techniques. I examine the effectiveness and cost of current management practices on the case study bus lanes. I suggest different practices that could be applied to the bus lanes based on a literature review.

**Operator Experience:** I deployed a short survey to 77 bus operators to assess their experience on these two bus lanes. These surveys queried operators on how frequently conflicts occur in the lane, and what types of conflicts occur the most (i.e. personal vehicles parked, or Uber/Lyft driving in the lane). There were also questions about how bus lane conflicts affect operator's perceived safety, security, and on-time performance.

**Roadway Safety:** I compare traffic-related collision incidence before and after both bus lanes were installed. For the Wilshire Boulevard bus lane, I compare total collisions, as well as incidence of collision types, four years before the installation of the bus lane, and four years after (I exclude 2015 as this was the year the bus lane was installed). For the Flower Street bus lane, I compare collisions for the Metro J Line and Metro 460 Line from June 2018-February 2019 and June 2019-February 2019.

**On-Time Performance:** I compare in-service on-time performance before and after both bus lanes were installed. For the Wilshire Boulevard bus lane, I compare on-time performance for the Metro 720 route four years before installation (2011-2014) and four years after the installation (2016-2019). For the Flower Street bus lane, I compare on-time performance for the Metro J Line from June 2018-February 2019 and June 2019-February 2019.

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Bus lanes in Los Angeles are primarily passively enforced through striping and signage. However, a recent bus lane pilot, called the "Flower Street Bus-Only Lane Pilot Project," is an exception. The a 1.8-mile downtown bus-only lane began operations in June of 2019 and relied on active enforcement by a highly-visible, dedicated unit of Los Angeles Police Department (LAPD) officers (See Figure 5 and Figure 6). This dedicated enforcement was funded through a

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<sup>16</sup> For more information on Los Angeles Metro, see Appendix A for key statistics on the agency.

\$350 million state-of-good repair program for Metro’s oldest rail line, the Blue Line, called the “New Blue Improvement Project.” The nature of the repairs required two four-month closures: a closure of the southern segment from January 26th to late May, 2019<sup>5</sup>, and a closure of the northern segment from June 1st to a projected completion date of September, 2019<sup>6</sup>. The Flower Street bus lane pilot project was developed to accommodate an increase in bus service during the second phase, from commuters traveling between downtown stations on temporary bus shuttles. This bus lane captured the attention of transit advocates and the riding public by speeding up buses on a heavily congested street. This success was largely due to the highly-visible dedicated police unit that patrolled the corridor.

The Flower Street project set a precedent for a new, more active enforcement strategy that contributed to overwhelmingly positive feedback from both riders and operators on the performance of the bus-only lane (See **Figure 3**).<sup>17</sup> From a short on-board survey conducted by Metro of riders and operators of the bus lane, two-thirds of customers experienced time savings, and three-quarters felt that it increased the reliability of the bus (“Metro Board Report: Flower Street Bus Lane Evaluation” 2019). Operator surveys had almost identical results.

**Figure 3:** The Flower Street Bus-Only Lane



*Photo taken by the author*

This enforcement strategy strongly contrasts with enforcement practices on all other mixed-use bus lanes in LA County. For example, LA Metro’s Wilshire Bus Rapid Transit (BRT) Corridor Project (See **Figure 2**), which includes a 15.4 lane mile bus lane and has been a target of criticism since its opening in 2015 due to high levels of motorist violations that make the bus lane largely ineffectual (Newton, 2018). Relying primarily on the passive enforcement techniques described above, this lane is lightly and inconsistently enforced by contracted LAPD vehicle patrols that are not focused on bus lane enforcement but rather safety and security on

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<sup>17</sup> A similar approach had been taken in 2004 with the installment of a six-month bus lane demonstration project on a one-mile stretch of Wilshire Boulevard. This bus lane, like Flower Street, was a temporary peak-hour bus lane with enforcement from LADOT parking officers.

Metro buses.<sup>18</sup> This lack of enforcement is mainly due to a lack of dedicated funding, and the fact that enforcing bus lanes has not been considered a part of the project costs of instituting a bus-only lane. However, this is not as simple as adding a line item to a future BRT project budget. Management of the bus lane, whether by adding striping, red paint, or enforcing the bus lane is outside of LA Metro's jurisdiction, and under the control of LA City and the other cities in Los Angeles County. Developing, funding, and deploying a management strategy thus requires strong interagency coordination.

LA Metro has committed to constructing three bus rapid transit projects in the next ten years, which will include an addition of approximately 75 lane miles of mixed-use bus-only lanes ("Twenty-Eight by '28," n.d.) (See Appendix A). As LA Metro, and other transit agencies across the US, continue to plan and invest in bus lanes, it is important to measure the impact of these investments and how to deploy and enforce these lanes most effectively. Bus lanes are increasingly becoming a tool that US cities are implementing, and a few of these cities have developed a comprehensive enforcement policy for these lanes (San Francisco and New York City both have automated bus lane enforcement programs).

LA Metro is also undertaking a massive redesign of its bus system. Called the NextGen Bus Plan, this redesign largely seeks to address recent and persistent declines in transit ridership due in part to reduce competitiveness of the bus. The bus system has not been significantly changed for 25 years, and many travel patterns have shifted in LA County ("NextGen Bus Plan," n.d.). Service inefficiencies, such as too many stops along a route, poor stop placement, and indirect routes, as well as rising traffic, contribute to slow and infrequent bus service. This results in reduced competitiveness with personal vehicle drive times. NextGen is addressing service-related issues by improving frequency, routing, and stop rationalization. However, the underlying issue of congestion limits the effectiveness of many of these service adjustments ("NextGen Regional Service Concept," 2019). Ultimately, having mixed-use bus lanes on most major arterials, in addition to the BRT corridors mentioned above, will be critical to the development of faster and more reliable bus service in LA County. However, enforcement will play a critical role in the management of these lanes to ensure they are effective.

The effect of unenforced lanes on the safety and on-time performance of bus operators has not been fully documented or quantified. The bulk of the research has focused on speed, load capacity, and reliability improvements, as these are just an emerging planning concept in US cities and are still relatively untested. Research on safety and operator experience is relatively more common within the literature on Bus Rapid Transit, as these are more prevalent around the world and have been studied more fully. Until better enforcement practices are instituted system wide, the issue of motorist violations will most likely only get worse as LA Metro grows its bus lane network.

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<sup>18</sup> Although the Wilshire Boulevard bus lane is not currently enforced, enforcement had initially been proposed to the LA City Council, and was seen as critical to its implementation. For more information, see Council File 03-2337-S1 titled "Wilshire Boulevard Bus Lanes"

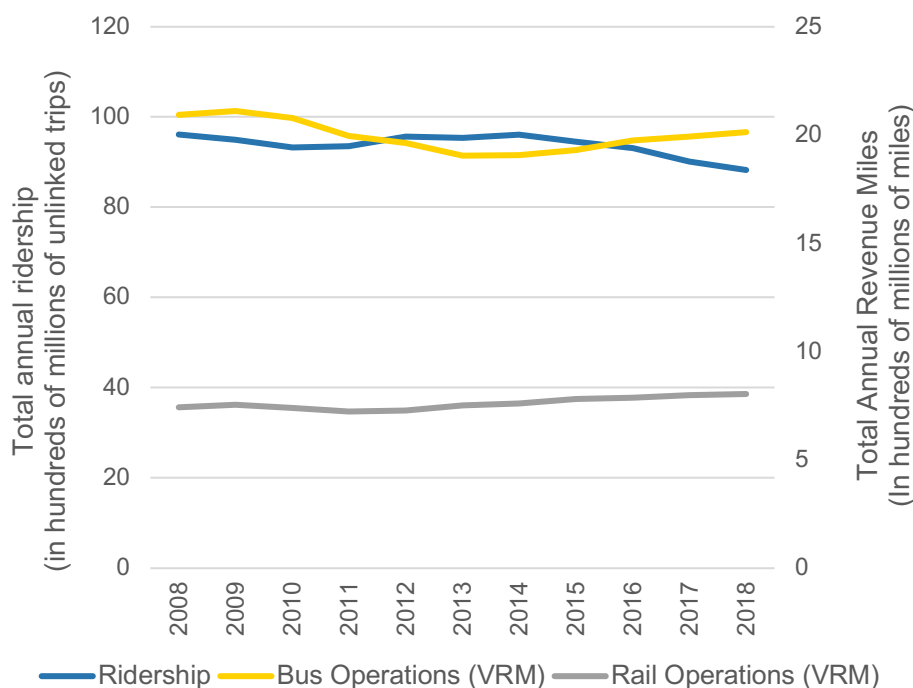


# Background

## Falling Ridership and a Re-Emphasis on the Bus

For the first time in decades, local bus service has been the focus of renewed attention from planners, advocates, and politicians in major US cities.<sup>19</sup> In every major city, the bus has been largely overlooked and relatively underfunded. Bus operations, as measured by annual vehicle revenue miles (VRM), have declined nationally by four percent since 2008, whereas rail operations have increased by eight percent, as seen in **Figure 4**.<sup>20</sup>

**Figure 4.** Annual transit ridership and operations for all US Agencies



*Source: data compiled by the author from National Transit Database (NTD) time series reporting. Methodology adapted from Boisjoly et al., 2018.*

Beginning in the US in the early 2000s, bus improvements in the form of Bus Rapid Transit (BRT), or buses that emulate rail systems with dedicated corridors, enhanced stations, and

<sup>19</sup> Planning, constructing, and extending light and heavy rail projects has historically been the focus of transit agencies in large cities nationwide, evidenced by a threefold increase of rail systems in major cities over the last thirty years (2018 APTA Factbook). Even in cities with legacy rail systems, such as New York City, much of the emphasis of planners, policy makers and advocacy organizations were focused on repairing these aging systems.

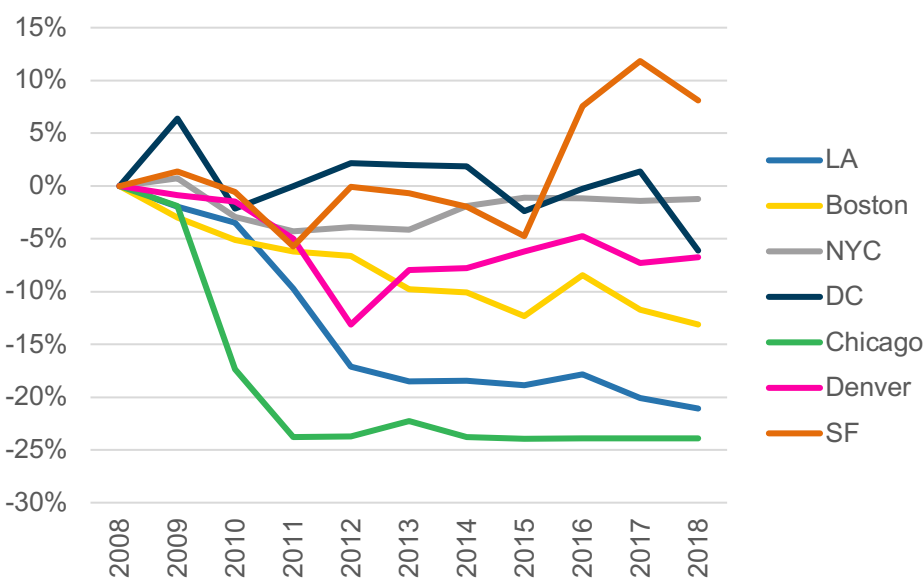
<sup>20</sup> Some of this reduction in Vehicle Revenue Hours and Vehicle Revenue Miles is due to service cuts as a part of a redesign, which seeks to increase efficiency of service by improving routing. This has a minimal effect on national totals, however. For more on this, see discussion in Boisjoly et al. 2018.

signal priority grew in popularity. However, these improvements often focus on particular corridors that have minimal impact on system-wide bus performance. Additionally, BRT corridor projects are treated as capital projects similar to rail, with major street redesigns and long project horizons. In Los Angeles and other major cities, where BRT projects have become heavily contested, long timelines combined with community pushback have resulted in stalled projects at threat of never being constructed.

A major turnaround in how US transit agencies approached bus improvement projects began around the mid-2010s. Bus networks in seven metropolitan areas underwent complete redesigns, and 12 other public transportation agencies or municipalities began planning redesigns (Higashide, 2019). These redesigns literally redrew the lines on the map of these bus systems, often for the first time in half a century. They instituted bus improvements such as more efficient stop spacing, improved frequency of high-ridership routes, and straightening out of circuitous routes. Additionally, many agencies instituted bus priority measures<sup>21</sup> to speed up the bus, including signal priority and queue jumpers, bus-only lanes, and other strategies.

This renewed emphasis on the bus in major metropolitan areas was largely driven by declining bus ridership nationwide. Where rail ridership has remained relatively steady or even grown in the US (due in large part to increases in service), bus ridership has been dropping in lock step with decreased bus operations, as seen in **Figure 4**. LA County bus ridership is among the worst performing of the seven major metropolitan areas depicted in **Figure 5**. LA Metro’s ridership has dropped 21 percent as of 2018 compared to 2008 levels (National Transit Database, 2018). San Francisco is the only metro area to have increased bus ridership since 2008, by eight percent as of 2018.

**Figure 5:** Percent change in bus ridership from 2002 in seven major metros areas



<sup>21</sup> See description of bus priority measures on pp. 3-4

*Source: author-made figure from National Transit Database time series reporting. Methodology adapted from Graehler, et al. 2019.*

As 15 operators within eight of the largest metropolitan areas carry 65 percent of the nation's unlinked passenger trips, major metro areas are largely responsible for the nation's ridership declines (National Transit Database, 2018). A leader in these parallel trends is New York City, which saw a 50 percent increase in heavy rail transit ridership from 2002 to 2018 at the same time that bus ridership fell by 30 percent.

Urban planners, politicians, and advocates have turned to the bus as both the cause and the cure of ridership declines. In the Southern California Association of Governments, or SCAG, region,<sup>22</sup> 86 percent of transit trips are taken by bus, and the bus accounts for 84 percent of ridership declines in the region. Although every city and region might face unique challenges, a suite of factors contribute to declining bus ridership across all these geographies. Much of transit's decline is due to external factors rather than plans and policies set in place by transit agencies and local governments. These factors include changing mobility patterns, higher automobile ownership, especially among foreign-born populations, competition from Transportation Network Companies, and changing demographics in urban cores ("Who's on Board," 2019; Manville et al., 2018).

However, there are also internal factors that affect bus transit's market share, including the cost, quantity and quality of the bus service for customers (Manville et al., 2018). National public transportation ridership losses have also not been uniform, with a few cities actually gaining ridership, such as Seattle and Houston. These cities gained the attention of the nation, as they had instituted system-wide improvements to their bus network that retained existing riders and attracted new ones (Higashide, 2019). These improvements were often referred to under the term "bus priority measures" and vary in their approach ("Bus Priority Treatment Guidelines," 2011). However, there are best practices that have been documented and distributed by organizations such as the National Association of City Transportation Officials (NACTO), leading to a standardized definition of bus priority in the US ("Transit Street Design Guide," 2016).

## Bus Priority Measures

Bus priority is defined as a suite of strategies used to allow buses to run faster and more reliably in congested environments. Bus priority involves changes to operations of bus systems, equipment, and the operating environment ("Bus Priority Treatment Guidelines," 2011). As detailed in a 2011 report called the "Bus Priority Treatment Guidelines" by the National Capital Region Transportation Planning Board, the suite of measures in a bus priority framework usually includes:

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<sup>22</sup> Includes all of Southern California counties except San Diego County.

## ***Operating Environment***

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**Bus-only lanes** (Exclusive guideway, mixed-use lanes, etc.), or dedicated facilities or lanes for the exclusive or semi-exclusive use of buses. An exclusive guideway bus lane operates in its own right of way, whereas mixed-use bus lanes operate in general-use traffic lanes.

**Curb extensions, bus stop bulb-outs, and boarding islands**, which allow buses to more easily pick up and drop off passengers, as they do not need to pull over to the curb. This can be done through concrete extensions of the curb or through prefabricated bus platforms, which are low-cost, quick-build plastic platforms that eases boarding for passengers and increases the visibility and attractiveness of the bus stop.

**Traffic engineering measures** (Signal retiming, Transit Signal Priority, Bus Queue Jump Signals), changes to the signal phases, or new phases, that allow buses to move more quickly through the intersection, reducing the amount of time that a bus is stopped at traffic lights.

**Regulatory measures**, such as turn restrictions for general traffic. This can reduce wait time for buses at intersections, and is specifically useful for right-turn movements, where buses are often delayed by a queue of vehicles at an intersection (particularly for near-side bus stops).

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## ***Operations of the Bus System***

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**Stop placement and rationalization**, or the repositioning, removal, or re-placement of stops to allow for more effective operations, while balancing the needs of riders.

**Route optimization**, or the straightening out and streamlining of bus routes to increase operational effectiveness. Additionally, this can mean combining different types of services (Express, Local, etc.) to reduce redundancy, and provide a more frequent network for riders.

**Express or tiered service**, or the development of special services (Rapid or Express service) to serve particular riders through higher-frequency service with fewer stops. Tiered service can also entail the elimination of such specialized services to simplify and enhance core service. This was used in Houston's METROs and LA Metro's bus redesigns.

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## ***Equipment***

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**Off-board fare collection**, which allow riders to purchase fare prior to boarding the bus, which can reduce bus dwell time at a stop.

**All-door boarding**, which allows riders to enter a bus at the rear doors as well as the front, reducing bus dwell time by spacing out passenger loading.

**Level boarding**, or the use of buses that do not require passengers to step up and down steps to board, and allow passengers with disabilities to board without ramps. This reduces dwell times at stops and enhances customer experience.

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(“Bus Priority Treatment Guidelines,” 2011)

Bus lanes are thus one treatment in a suite of tools for bus priority. Most of these measures are most effective when implemented as a part of a suite of changes (“Bus Priority Treatment Guidelines,” 2011). This is because most priority measures alone, such as signal retiming, have only a small effect on speeding up bus operations, particularly in congested environments. By combining these strategies, cities and agencies have the best chance to maximize bus speed and reliability improvements.

Some priority measures do have a greater impact than others on improving bus speed. However, these measures are usually (but not always) resource and cost intensive to implement. Decision-makers must balance several factors when instituting these priority measures—whether they can be implemented given space, time, and financial constraints, as well as the scope of priority needed based on the bus service level (Agrawal et al., 2013). For example, a bus route that has five-minute headways in a high-ridership area might warrant more investment and greater priority than a route that serves a lower-density and lower-ridership area.

For the purposes of this report, I focus on changes to the operating environment, specifically bus-only lanes (see Appendix B: Bus Priority Measures for a description of traffic engineering measures). Making changes in the operating environment are often the most effective forms of bus priority, however, they are also often the most challenging. This is because in most US cities, including in Los Angeles, transit agencies do not control street rights-of-way. While such control issues are typically easier with municipal transit operators, where both the transit agency and streets and public works departments are part of the same local government, they are rarely easy. Transit agencies like LA Metro must develop and work through multi-jurisdictional partnerships with municipal departments of transportation, which may have very different priorities for the allocation of street space than a transit operator. Oftentimes, myriad other municipal departments must be involved as well.

## ***Bus-Only Lanes***

A bus-only lane is a dedicated right of way for public transportation buses that can be restricted to car traffic in a variety of ways and can allow for faster and more reliable bus service (Agrawal et al., 2013). There are a variety of approaches to designing, implementing, and managing bus lanes. A busway or transitway, by comparison, provides an exclusive right of way for buses that is completely separated from traffic (“TCRP Report 118: Bus Rapid Transit Practitioner’s Guide,” 2007). A busway produces fewer conflicts with motorists, and is easier to manage due to strict separation of buses and unrestricted lanes of traffic. A mixed-use bus lane can be easier to implement as they only require the conversion of a curb lane for buses, and allow for certain users to share the lane, such as bicyclists and right-turning motorists. Bus lanes can also be offset from parking and loading zones to increase priority, or moved into the median, which reduces the possibility of lane

conflicts. Additionally, reconfiguring the street to allow for raised barriers or delineators between the general use lanes and bus lanes can also increase priority, but this strategy has not been widely used in the United States, except for a few cities like Seattle and New York City (See **Figure 6**).

**Figure 6:** A bus lane separated by delineators at the intersection.



*Source: New York City MTA*

The application of bus lanes and busways in the US dates back to the mid-1950s but falls in several general categories, including within Bus Rapid Transit (BRT) systems, and more recently, bus lanes that have been implemented outside the context of BRT projects. BRT is similar to bus priority but often requires large capital improvements, such as an exclusive guideway bus lane, bus stops that look and work like stations, off-board fare collection, signal priority, and other customer experience improvements. BRT has been widely used in South America, Europe, and Asia, but US cities often take a piecemeal approach to instituting bus improvements, Cleveland being an exception (“TCRP Report 118: Bus Rapid Transit Practitioner’s Guide,” 2007). US cities are using bus lanes, in particular, for addressing specific congestion hotspots that affect large numbers of riders.<sup>23</sup> This application of bus lanes has been coined “tactical transit lanes,” which borrows from a broader movement called tactical urbanism, or low-cost and quick-build street improvements that allow for immediate, temporary changes to the streetscape that can expedite longer-term improvements (“Best Practices in Implementing Tactical Transit Lanes,” 2019).<sup>24</sup> Although there are benefits to these spot fixes, there are some drawbacks that come from greater needs for management and enforcement of the lane.

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<sup>23</sup> For example, there are seven miles of “bus slow zones” in the city of Boston that have been identified to carry one-fifth of the MBTA’s bus riders, and cause major delays for these riders. Source: [https://www.itdp.org/wp-content/uploads/2019/10/Julia-Wallerce\\_11.6.2019.pdf](https://www.itdp.org/wp-content/uploads/2019/10/Julia-Wallerce_11.6.2019.pdf)

<sup>24</sup> Tactical urbanist strategies, such as street paint to designate pedestrian zones, and planters and barriers to protect pedestrians and bicyclists, are often geared towards a variety of objectives, such as reducing traffic deaths, improving the experience of non-auto users, and enhancing street life. Read more at: <http://tacticalurbanismguide.com/about/>

Bus lanes can be classified based on the “scope of priority” they receive on the street (Agrawal et al., 2013). Agrawal et al. write that bus lane management is a balancing act, where:

*This balance can be achieved in multiple ways, such as allowing other vehicles to access the bus lane under defined conditions, scheduling different uses for the lane during different times of day, and positioning the bus lane to change the mix of users affected by the bus lane’s presence (2013, p.38).*

This balance has to arise from what is politically and contextually feasible, especially in the instance of management, but also from other constraints, such as cost, roadway space, and institutional arrangements. Additionally, planners also have to do some “political calculus” on whether a certain lane design modification will gain the support or opposition of a council district or neighborhood association. In Los Angeles County, this political component is front-of-mind for planners, as the Wilshire Boulevard Bus Lane, along with others, received vehement opposition from some municipalities and special interest groups (“Mid-City/Westside Transit Corridor Draft EIS/EIR”, 2001; Newton, 2010; Hymon, 2011).

## ***Defining and Evaluating Bus Lane Management Practices***

Management of bus lanes falls into three categories: design solutions, passive enforcement, and active enforcement techniques. Passive techniques include the use of regulatory traffic devices, such as striping (white lines or red painted lanes) and signage to guide and educate roadway users and encourage compliance. Active enforcement includes warning, ticketing or towing vehicles that are using the lane illegally through deploying police, parking officers, or using bus lane cameras that can detect license plates of motorists and issue fines through automated processes.

Cities or transit agencies are jurisdictionally-constrained to a certain set of defined tools for managing bus lanes. This is due in part to the fact that law enforcement has to be involved in most contexts (Agrawal et al., 2013). The best solutions they saw arise from case study cities were to turn bus lane infractions into civil penalties with administrative processes rather than criminal ones, and to develop “contractual or supervisory relationships between police and transportation agencies to ensure that there were personnel directly responsible for bus lane enforcement” (Agrawal et al., 2013). The criteria for “best” in this context were lanes that were able to be monitored and enforced the easiest, with minimal needs for coordination with law enforcement.

### Design Solutions

Different design solutions can increase the scope of priority offered in the bus lane (See **Figure 7**). Mixed-use bus lanes that use curbside lanes offer the least priority, whereas busways offer the most. This is due to the fact that design solutions can reduce the likelihood of lane intrusions. A busway requires the least amount of enforcement, as the lane



is completely separated from traffic or personal automobiles are banned from the street (See **Figure 8**).

**Figure 7: Bus Lane Design Measures, by Scope of Priority**



*Figure created by the author*

However, this is not to say that busways do not benefit from enforcement, and many cities, including Los Angeles have red-light cameras along its busways, such as on the G Line in Los Angeles (See **Figure 8**).<sup>25 26</sup>

**Figure 8: G Line Busway in Los Angeles**



*Source: LA Metro*

Mixed-use lanes offer greater flexibility than busways that make it a more pragmatic solution for cities, especially in the US, where there is limited existing capacity on the street. Often, mixed-use bus lanes are implemented in places where designating a fully-dedicated right of way for buses would be impractical or infeasible (Agrawal et al. 2013). Despite this benefit, these lanes are more likely to be subject to more legal and illegal lane intrusions and motorist violations, and slower bus speeds as a result (Safran et al., 2014). Mixed-use bus lanes are also often implemented in places that are more congested, such as urban cores, which makes enforcement even more of a challenge as violations are more rampant. Some designs are more prone to intrusion, such as a right-hand curbside bus lane, where motorists can illegally park, and where high numbers of legal movements cause greater conflict in the lane, such as right-turning vehicles (Safran et al., 2014). Additionally, many

<sup>25</sup> Formerly called the Orange Line. For more information on LA Metro's change to line letters, go to [metro.net/projects/line-letters/](https://metro.net/projects/line-letters/)

<sup>26</sup> Metro owns the right of way along its busways, which gives the agency jurisdiction to enforce through automated strategies. Metro has installed red light cameras along the bus corridor at intersections where cross-traffic might block the lane. This is primarily a safety measure. For more information on Metro's red-light camera program and associated costs, see Metro Board Report *File #2019-0547 – Metro's Photo Enforcement Program* at <https://metro.legistar.com/Legislation.aspx>



mixed-use bus lanes in the US allow for bicyclists to use the lane, which can create additional conflicts and time delays (Keeling et al., 2019).

Different design solutions can also offer an intermediary option between a mixed-use curbside lane and busway. Many of these have been solutions have become standardized in guides such as the Transit Street Design Guide which is produced by the National Association of City Transportation Officials (NACTO). Solutions are described below and visualized in **Figure 9**:

- Creating a floating or parking adjacent lane, where the bus lane runs in the right-hand lane but is offset from the curb by street parking, curb extensions or raised cycle tracks (“Offset Transit Lane”, n.d.)
- Placing the bus lane in the center of the lane, running with traffic. This allows for less conflict at intersections from right-turning vehicles. However, center running lanes often require additional infrastructure to allow passengers to board and alight the bus, as the bus would have to leave the bus lane to access a curbside bus stop. Regulatory measures, such as restricting left turns for general traffic along the bus lane can also be used in tandem with this approach (“Transit Street Design Guide,” 2016).<sup>27</sup>
- Tiered transit streets, which include dual bus lanes on one-way streets. This allows for in-lane stops, where a bus can stop in the lane rather than pull to the curb. This can be accomplished by designating the right-most lane for stopping, and the outer right bus lane for travel. This reduces delay caused by other buses (“Transit Street Design Guide,” 2016).

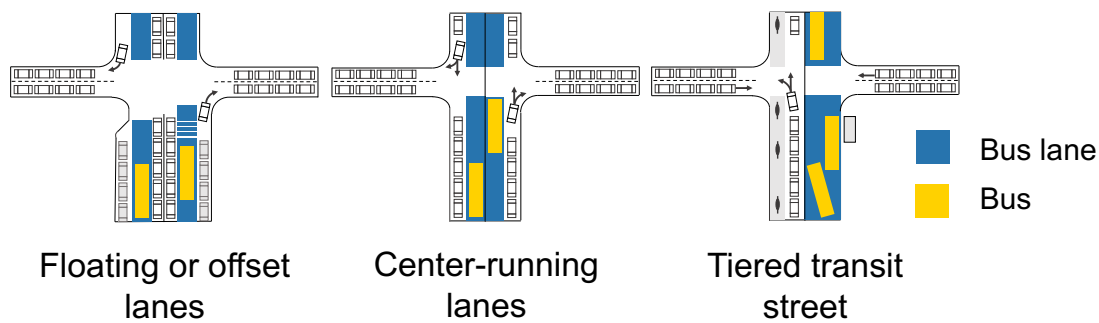
Adding physical barriers or delineators<sup>28</sup> that create a separated lane, particularly at the intersection (See **Figure 6**).

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<sup>27</sup> See description under Bus Priority Measures – Regulatory Measures (page 7)

<sup>28</sup> Delineators are defined in the California Manual on Uniform Traffic Control Devices (MUTCD) as a “a retroreflective device mounted on the roadway surface or at the side of the roadway in a series to indicate the alignment of the roadway.” Delineators are commonly used to mark bike lanes, and delineators such as rigid bollards have been used to mark bus-only lanes. See more at: <https://dot.ca.gov/programs/traffic-operations/camutcd>

**Figure 9:** Representation of different design solutions for improving mixed-use bus lanes.



*Depiction of three intermediary bus lane treatments. Floating lanes allow for parking on the curbside, and can be striped in areas where right-turn motions are allowed. Center-running lanes disallow left turn movements across the bus lane to reduce the likelihood of collisions. Tiered transit lanes typically apply to one-way streets, where two lanes are dedicated to buses. A one-way cycle track is depicted on the left curbside lane of the tiered transit street. Source: author-made figure based on standardized treatments in the NACTO Transit Design Guide, 2016)*

A few studies have quantified the benefits of such design techniques. Safran et al. (2014) assess how offset bus lanes, which are increasingly being implemented in New York City, and find no statistically significant effect of offset lanes on violation levels.

#### *Time and Mode Restrictions*

Bus lanes can also have different mode and time-based roadway restrictions. Although most US mixed-use bus lanes allow only buses, bikes, and emergency vehicles, some US cities, such as San Francisco, also allow taxis in the bus lane. This has caused issues particularly with the rise of ridehailing apps (i.e. Uber and Lyft). Ridehailing, also called ridesourcing, is the use of online platforms to connect customers to drivers for on-demand car service (Feigon & Murphy, 2016). Some cities have created explicit policies that ban ride-hailing vehicles from using the bus lanes (Fowler, 2019). Bikes in the bus lane have also caused a fair amount of debate among planners and policymakers due to safety concerns (Kosinski et al. 2017; Hillsman et al., 2012).<sup>29</sup> Despite concerns, most research suggests that lanes that incorporate both bikes and buses—called Shared Bus-Bike Lanes (SBBLs) can be implemented safely if the proper standards are followed—such as the National Association of City Transportation Officials (NACTO) guidelines for SBBLs (“Shared Bus-Bike Lane,” n.d.).

However, evidence suggests that bikes can reduce the travel speeds of buses and thus lower the performance of the bus lane (“A Summary of Design, Policies and Operational Characteristics for Shared Bicycle/Bus Lanes,” 2012). Some cities have chosen to separate the bike and bus lanes on streets with high bus volumes, or create separate channels for bikes

<sup>29</sup> See Operator Experience section for more details on safety and shared-bus bike lanes (SBBLs)

around bus stops to allow bikes to “leapfrog” the bus (Hendricks & Koos, 2012). Both of these strategies have been implemented in cities such as Chicago (see **Figure 10**). However, limited street space can make this challenging (“Chicago’s first BRT to speed up east-west travel in Loop,” 2015).

**Figure 10:** Cycle track and bus lane configuration in Chicago



*Schematic of separated cycle track (in green) to the left of the mixed-use bus lane (Photo credit: Keith Privett)*

In addition to modal restrictions, some bus lanes implemented in the US are peak-only, meaning that they are only operational during rush hour traffic periods. The bus lane case studies in this report, the Wilshire Boulevard and Flower Street bus lanes, are peak-only. Wilshire Boulevard is operational in both morning and evening peak (7-9 am and 4-6 pm), whereas Flower Street only operates during the evening peak period (3-7 pm). This is often used as a strategy to maximize roadway capacity and parking availability during non-peak times (Kiesling & Ridgway, 2006). For example, the Flower Street bus lane allows for parking in the lane during off peak hours.

However, there is evidence that other forms of time-based roadway restrictions, such as peak-hour turn prohibition signs and no parking zones, can confuse drivers and be less effective in places where regulations are poorly enforced (“State of the Art Report: Residential Traffic Management,” 1981; “Turn Restrictions,” n.d.). The application of peak hour time restrictions to bus lane effectiveness has not been fully studied. However, preliminary evidence on San Francisco bus lanes suggests that 24-7 bus lanes have lower rates of motorist violations. This may be due to the fact that the regulations are clearer, which leads to less confusion by motorists over whether or not they can drive and park in the bus lane (Kiesling & Ridgway, 2006).

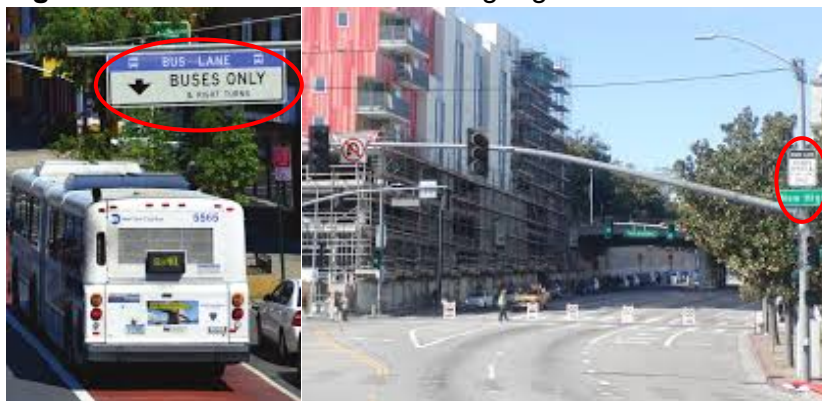
Normally, fixed-post signage is used to communicate peak-hour restrictions along the bus lane, as well as occasionally pavement marking. In some European cities, peak-hour bus lanes have been implemented through a different approach. Called Bus Lanes with Intermittent Priority (BLIPs) these bus lanes allow for general traffic to use the lane when a bus is not present. When buses approach, they activate a signal that creates an alert for

motorists to exit the lane, often through electronic road signs and in-pavement lights that flash (Chiabaut & Barcet, 2019).<sup>30</sup>

### Passive Enforcement

Passive enforcement includes techniques that educate and encourage compliance, such as roadway striping, bus-only lane signage, and red-painted lanes (Agrawal et al., 2013). Passive enforcement techniques are most commonly deployed in bus lanes due to requirements set at the state level for roadway striping and signage through the California Manual of Uniform Traffic Control Devices (MUTCD). However, there are more experimental measures that cities are taking to enhance passive enforcement techniques, such as red-painted bus lanes. Additionally, there are some passive enforcement practices that offer greater visibility and are possibly greater at encouraging compliance (Agrawal et al., 2012). For example, the standard for bus lane signage in New York is on overhead gantries, where in Los Angeles, bus lane signage on some streets is placed above eye-level, offset from traffic signals (See **Figure 11**).

**Figure 11:** Differences in bus lane signage standards



*Bus signage is highly visible on overhead gantries New York City bus lanes, and barely visible on Cesar Chavez Boulevard in Los Angeles (Source: NYC MTA and LA Metro)*

### *Red-painted lanes*

There is little consensus on the efficacy of red painted lanes in reducing violation rates. This is due to the fact that the Federal Highway Administration still considers this treatment as an “experimental” traffic control measure, and has only recently granted interim approval to cities and agencies looking to paint red lanes.<sup>31</sup> Safran et al. analyze how red-painted lanes in New York City affect violation rates, and found there was no statistically significant effect

<sup>30</sup> This is similar to the approach used for at-grade light rail crossings, where there is an electronic sign denoting light rail crossing.

<sup>31</sup> For experimental traffic control measure implementation, the Federal Highway Administration requires a city to issue a request for experimentation, get approval, and conduct a study of the approach. This was the case for red painted bus lanes up until December 4, 2019, when the FHWA granted interim approval for all cities looking to use red colorized bus lanes. Cities now just have to follow the standards set by Item D in Paragraph 18 of Section 1A.10 of the 2009 MUTCD. For more information, see: [https://mutcd.fhwa.dot.gov/resources/interim\\_approval/ia22/index.htm](https://mutcd.fhwa.dot.gov/resources/interim_approval/ia22/index.htm)

of bus lane colorization and minimal effect of offset bus lanes on violation levels (2014). The authors also analyze how red-painted lanes and bus lane offsets in New York City affect the usage of the lane by MTA bus operators. There was a statistically significant effect on the bus operators use of the bus lane, and operators were much more likely to use the lane when it was both red and offset (Safran et al., 2014).

An evaluation report from the San Francisco Municipal Transportation Agency (SFMTA) found that red painted bus lanes reduce violation rates by 51 percent (See **Figure 12** for an example of a San Francisco red painted bus lane).<sup>32</sup> Additionally, SFMTA saw a decrease in collisions involving buses within three study corridors (“Red Transit Lanes Final Evaluation Report,” 2017).<sup>33</sup> The National Capital Region Transportation Board conducted a study in 2017 that found that paint is one of the most expensive enforcement strategies (behind police and parking enforcement) and offers the least benefit. This report found that red painted lanes cost approximately \$308,000 per mile to install, and an additional \$10,000 per mile to maintain (“Bus Lane Enforcement Study,” 2017).<sup>34</sup>

Although not studied in the context of red-painted bus lanes, other traffic engineering measures –such as red-light cameras and speed cameras—have been found to have “spillover effects” or essentially reduce the overall effectiveness of non-treated roadways. In the context of red-light cameras, intersections without this treatment might experience higher violation rates. This concept of a spillover effect, also called a “novelty effect” is a core consideration of traffic engineering. This motivates the use of standardized, uniform traffic control devices. In the context of red-painted lanes, if one bus lane within a city was painted red and the rest were not, it might reduce the effectiveness of other bus lanes. Thus, many cities, such as San Francisco and Portland, have systematically painted all their bus lanes red in order to minimize this effect (“Red Transit Lanes Final Evaluation Report,” 2017; “Rose Lane Project,” 2020).

**Figure 12:** Red-painted, center-running transit and bus lanes in San Francisco



<sup>32</sup> Unlike the study by Safran et al. this was not a controlled study.

<sup>33</sup> SFMTA saw a 16 percent decrease in bus related collisions between 2013 and 2015. Citywide, there was a 23 percent increase in bus collisions.

<sup>34</sup> If LA Metro’s whole mixed-use bus lane network were to receive this treatment, it would cost \$8.3 million in upfront costs and an additional \$270,000 per year to maintain, based on the author’s calculations.



Source: SFMTA

### Active Enforcement

Active enforcement is the use of parking enforcement officers, police officers, and/or automated technologies to enforce bus lanes. Different types of active enforcement provide varied benefits. A dedicated police unit can often issue both moving and parking violations, whereas parking officers can issue only parking violations (see **Figure 13**).<sup>35</sup>

**Figure 13:** Los Angeles Police Department towing a vehicle on the Flower Street bus lane



*Photo taken by author*

Labor costs are typically much higher for police officers than parking officials. There are also equity issues involved with deploying police officers. LA Metro, as well as other US transit agencies, have decriminalized fare enforcement by removing criminal penalties for evasion. Fare evasion and most minor rider violations are processed as administrative fines through LA Metro’s transit court rather than through city courthouses (Metro Transit Court, n.d.). Parking fines on LA Metro property and right of way are treated similarly. Decriminalizing fare enforcement can reduce the burden of policing on particularly African American and Latino individuals, which are disproportionately arrested, as well as the risk of deportation for immigrants on the transit system (“Why Decriminalize Fare Evasion?” 2019).<sup>36</sup> However, this does not address underlying bias in enforcement. A civil claim from 2018 showed that LA Metro transit officers were still disproportionately fining black riders (Tinoco, 2018).

### *Dedicated enforcement and “blitzes”*

Enforcement blitzes typically entail dedicated police deployed for the sole purpose of enforcing the bus lane and maintain enforcement for most of the time the bus lane is operational. Enforcement blitzes use police or parking officials in large numbers for short

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<sup>35</sup> In most states, including California, only sworn peace officers can issue moving violations, as well as parking violations.

<sup>36</sup> Evidence suggests that fare enforcement disproportionately affects African American individuals. From a fare evasion study in Washington DC and New York City, researchers found that in DC 91 percent of those cited are African American, and in New York City, 94 percent of those arrested are people of color. Many people consider fare evasion to be a “crime of poverty” and leads to unnecessary incarceration, employment loss, housing insecurity, and heightened risk of deportation. See more at: <https://transitcenter.org/why-decriminalize-fare-evasion/>

periods of time. There is evidence that these strategies are effective. A study from Washington, DC (“Bus Lane Enforcement Study,” 2017) found dedicated police enforcement to be moderately effective, but the most cost-intensive of enforcement techniques evaluated. A study of bus lane enforcement blitzes from Dublin, Ireland found that in the peak periods, bus travel times were less than for cars but in off-peak periods the reverse was more common, which suggests fewer lane intrusions (O’Mahony, 2002).<sup>37</sup> However, deploying police officers to enforce bus lanes introduce the chance for bias, and increases the criminalization of transit-related enforcement.

Enforcement blitzes have been used in Los Angeles to remove parked cars from bus lanes and encourage compliance. These blitzes are led by what are called “Tiger Teams” or Total Integrated Gridlock Enforcement Resources, and rely on a highly-visible, intermittent towing strategy led by the Los Angeles Department of Transportation (LADOT) parking officials (Guccione, 2006).<sup>38</sup> As discussed in the previous section, parking officers can only issue administrative fines. Thus, using parking officials to enforce bus lanes, rather than police officers, has the benefit of decriminalizing bus lane enforcement.

#### *Automated Bus Lane Enforcement*

Another option for active enforcement that does not require boots-on-the-ground, and could limit the opportunity for bias, as well as reduce labor costs, is automated camera enforcement. Automated enforcement is the use of cameras installed in the bus lane or on the transit vehicle that can detect violations, read license plates, and streamline the issuance of violations. Automated enforcement camera systems are capable of enforcing both moving and parking violations, however, they are most often used to enforce parking violations.

The National Capital Region Transportation Board Bus Lane Enforcement Study (2017) found that compared to active police enforcement, automated enforcement can have significant fiscal and enforcement benefits. One difference between this study and international findings is the ideal location for the camera—transportation officials in the US appear to prefer cameras mounted to the front of buses, whereas transit officials outside of the U.S. more often use fixed post or gantry mounted cameras (Agrawal et al., 2012).

Evaluations conducted by public agencies and researchers in the US and globally on the efficacy of different bus lane enforcement techniques show differing results, though with some overlapping findings. The most significant common finding is that transportation officials in most cities consider automated bus lane enforcement, using cameras to detect

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<sup>37</sup> It is important to note that Dublin combines dedicated enforcement blitzes with CCTV cameras that offer 24/7 monitoring of the bus lane, and help police determine where violations are happening in real time before they are deployed on a location.

<sup>38</sup> Tiger Teams was a high-profile strategy of LA’s former Mayor, Antonio Ramón Villaraigosa to address rush hour traffic. Villaraigosa set aside \$1 million in 2006 for the rapid response Tiger Teams to enforce anti-gridlock zone policies. An anti-gridlock zone is an area where curbside parking is prohibited during peak hours, and is used extensively on high-trafficked streets in the City of Los Angeles. Parking fines are usually doubled in these zones. These Tiger teams were used on Wilshire Boulevard in 2006 on an earlier version of the bus lane (Guccione, 2006)

and mail citations to violators to be a best practice (Agrawal et al., 2012). Automated camera technology, if implemented correctly, can also reduce the likelihood of bias seen in active policing (Poston, B. & Chang C., 2019; Council et al., 2015; “Speed Enforcement Camera Systems Operational Guidelines,” 2008).<sup>39</sup> <sup>40</sup> However, decisionmakers must ensure that these cameras are placed without effort to target disadvantaged and minority communities, and strict data protections must be put in place to ensure camera footage is not used for other purposes.

Agrawal et al. argue that all these enforcement techniques (active, passive, and design solutions) should be used together to encourage compliance and reduce conflicts (2013). Different techniques, such as colorized lanes, automated camera enforcement, and offset bus lanes have been quantified in a few studies but the effects of enforcement are not well understood (Safran et al. 2014; Dudata et al. 2015; O’Mahony, 2002). Kiesling and Ridgeway argue that beyond affecting the bus lane’s operations, the placement of a bus lane affects the operations of an entire street, which makes it difficult to quantify the full impact of a bus lane (2). Kiesling et al. and Agrawal et al. argue that making the lane as conflict-free as possible via “self-enforcing” will ensure success, but do not provide quantifiable evidence for this argument (Kiesling & Ridgeway, 2006; Agrawal et al., 2013).

## ***Bus Lane Management and Operator Experience***

There is limited research on traffic safety in busways or mixed-use bus lanes (Duduta et al. 2015; Keeling et al., 2019), and also limited literature on how bus lanes management practices affect bus operator safety and performance. An emerging area of research focuses on bike-bus interactions and safety in the what are referred to as “shared bus bike lanes” or SBBLs (Kosinski et al. 2017; Hillsman et al., 2012). However, these studies specifically call out the need for empirical studies looking at collision levels in different cities and for different designs of SBBLs (Hillsman et al., 2012). Some studies have quantified the effect of different management techniques on bus on-time performance, but few consider how this affects the experience of the operator (O’Mahony, 2002; “Wilshire BRT: Before and After Report,” 2017; Keeling et al., 2019; Kosinski et al., 2017). This is a gap that this research seeks to fill.

Two previous studies conducted by LA Metro lay the groundwork for my analysis, includes useful insights on operator experience as well as roadway safety, the “Wilshire BRT: Before and After Report” (2017) and Kosinski et al.’s Bike-Bus Interactions study (2017).

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<sup>39</sup> Additionally, agencies should build in data protections and retention policies so that footage does not get used for uses outside of bus lane enforcement. For an example, see data protections within AB 1287, the legislation that allowed a local exemption for San Francisco’s automated bus lane enforcement program. See more at: [http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab\\_1251-1300/ab\\_1287\\_cfa\\_20150506\\_123230\\_asm\\_comm.html](http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab_1251-1300/ab_1287_cfa_20150506_123230_asm_comm.html)

<sup>40</sup> There is strong evidence for bias within US police departments, most prominently against African American and Latino individuals. For evidence of this among LAPD officers conducting vehicle stops, see Poston B. & Chang C., 2019.



### Wilshire Before and After Study (2017)

LA Metro commissioned a “Before and After” study to determine how the Wilshire bus lane impacted various factors, including level of service, bus travel times and on-time performance (“Wilshire BRT: Before and After Report,” 2017). The majority of bus operators agreed that the bus lane improves service reliability and on-time performance. Operators’ primary concern was bus lane violations, with:

- 40 percent of operators stated that general traffic illegally driving in the lane was an issue,
- 14 percent of operators thought the presence of bicyclists was an issue,
- 12 percent of operators indicated that temporarily-parked commercial vehicles (defined as delivery vehicles or Uber or taxis in the lane) was an issue, and
- 9 percent expressed that parked private vehicles were a problem.

Additionally, operators stated that the most important benefit of the bus lane was the ability to bypass vehicular traffic (29%) and the ability to maintain a timely schedule (23%). This report provides a qualitative measure of safety as perceived by operators. According to the study, “operators perceived improved safety from less bus maneuvering through traffic and easier accessibility for boarding and alighting as a result of bus lane implementation” (“Wilshire BRT: Before and After Report,” 2017, p. 35). Lastly, bus operators weighed in on potential strategies to improve the bus lane:

- 49 percent of operators thought that more enforcement and monitoring would be the best solution for removing motorists from the bus lane
- 12 percent of operators expressed that the lanes could be more effective without bicycle and right turning vehicle access

I directly compare my results to these findings. My empirical analyses of roadway safety provide a more in-depth look at the safety outcomes of bus lanes. One limitation of this study is that it groups different types of conflicts together in survey questions (i.e. delivery vehicles and Uber vehicles) I disaggregate types of conflicts causing delay in the bus lane to take a more nuanced look.

### Bike-Bus Interactions Study (2017)

LA Metro staff conducted a study along with a consulting group, Fehr & Peers, that focused on bike safety, specifically bus-bike interactions in shared bus-bike lanes (SBBLs). The study team analyzed collision incidence along three bus lanes in Los Angeles, Sunset, Figueroa, and Wilshire Boulevard and find that there was no increase in bike or bus collisions due to the presence of SBBLs (Kosinski et al., 2017). These findings inform my collision incidence research.

## Data and Methods

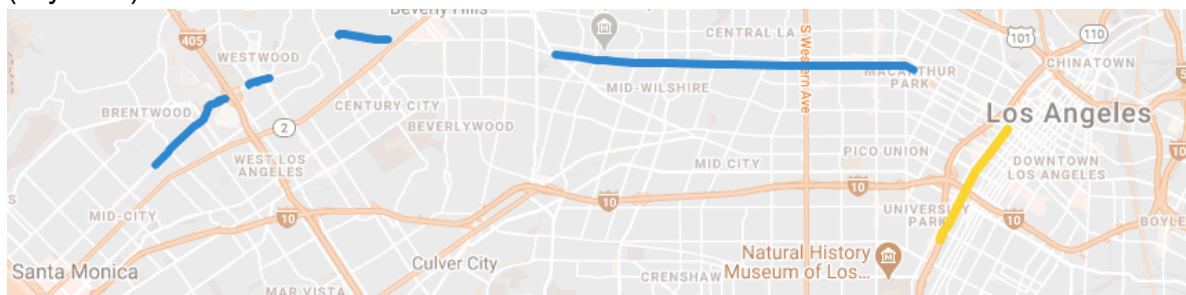
The key components of the study methodology are review of internal LA Metro memoranda and reports on bus lane enforcement, the deployment and analysis of bus operator surveys, and analyses of in-service on time performance and collision incidence data. Interviews with staff in key departments at LA Metro and a review of documentation related to bus lane design and management also inform the study and design of the survey instrument. The survey helps to fill gaps in current understanding of how bus lane enforcement affects LA Metro's bus operations, and this is paired with empirical data on crash incidence and on-time performance reporting. I also rely heavily on past bus lane research conducted by LA Metro. I use these data in a comparative analysis of two case study corridors, the Wilshire and Flower Street bus-only lanes.

The study compares these survey findings with reporting data on on-time performance and collision incidence. All these data are used to examine differences in bus on-time performance, incidence level, and operator experience across the two case study corridors, and at different time points (such as before and after installation of the lane). For example, the study looks at Flower Street both pre- and post- installation, to determine if on-time performance and collision levels changed with the installation of the bus lane, and the role of bus lane management in these factors.

### Case Study Comparison

This research examines two different bus-only lanes (cases) in the City of Los Angeles, the Flower Street and the Wilshire Boulevard bus lanes (see **Figure 14** and **Table 1**). The goal of the study is to investigate bus operator experience and management practices for bus lanes, primarily focusing on enforcement techniques utilized between June 2019 and January 2020 (when the Flower Street Bus-Only Pilot was in effect). These two dimensions (bus operator experience and enforcement of bus lanes) are interconnected, as unenforced lanes present many challenges to operating a bus, and operators' first-hand experiences can provide useful data on where violations are happening and what types of violations have the biggest impact on bus service.

**Figure 14:** Map of the case study bus lanes on Wilshire Boulevard (in blue) and Flower Street (in yellow)



The Wilshire Boulevard bus lane (on the left, in blue) and Flower Street bus lane (on the right, in yellow) (Source: author-made map based on LA Metro infographics)

**Table 1:** Description of case study bus lanes

BUS LANE LOCATION	YEAR OPENED	LENGTH (LANE MILES)	OPERATING HOURS	CAPITAL COSTS	MANAGEMENT STRATEGIES
<b>Wilshire Boulevard</b>	Partial opening in 2013; fully opened in 2015	15.4 (7.7 bi-directional miles)	7-9 am; 4-7 pm	\$31.5 million	Striping and signage; transit vehicle patrol
<b>Flower Street</b>	Temporary pilot began in June 2019	1.8	3-7 pm	\$75,000	Striping and signage; dedicated police unit

Source: author-made table from research, with information from LA Metro

#### Wilshire Boulevard Bus-Only Lane

The Wilshire Boulevard bus-only lane is peak-hour (operational from 7-9 am and 4-6pm) and mixed-use, allowing for the use of right turning vehicles and bikes. The bus lane is a part of a Bus Rapid Transit project on Wilshire, which includes transit signal priority<sup>41</sup> and bus shelter redesigns. The bus lane is bidirectional, running 7.7 miles, or 15.4 lane miles, from MacArthur Park area to the Eastern edge of Santa Monica (between South Parkview Street to Centinela Avenue, with breaks). These breaks are the product of community opposition that pushed LA Metro to abandon certain segments of the bus lane in order to move ahead with the project. For example, there is no bus lane where Wilshire passes through the Beverly Hills neighborhood. A 1.8-mile segment of the Wilshire Boulevard bus lane opened in April 2013, but the majority of the bus lane was opened in 2015 (Broverman, 2013; Lemon, Apr. 2015; Lemon, Nov. 2015).<sup>42</sup>

Striping and signage are used as passive enforcement techniques, and no design strategies have been used to minimize conflicts. Metro does not have a special enforcement budget,

<sup>41</sup> For more information on transit signal priority, see Appendix C: Traffic Engineering Measures

<sup>42</sup> This segments that opened in April 2015 included the following: Western Avenue to San Vicente Boulevard, another segment on the eastern boundary of Beverly Hills to Comstock Avenue; and another from Selby Avenue to Veteran Avenue, and from Bonsall Avenue to Federal Avenue. This added to a 1.8 stretch from MacArthur Park to San Vicente Blvd opened in 2013. In November 2015, the final segment from Federal Avenue to Centinela Avenue in West LA opened. For more information, see: <https://thesource.metro.net/2015/04/07/longest-segment-of-wilshire-brt-bus-lanes-set-to-open-on-wednesday/> and <https://thesource.metro.net/2015/11/13/final-segment-of-wilshire-peak-hour-bus-lanes-to-open-in-west-l-a-on-monday/>

but rather contracts vehicle patrol officers, whose primary directive is safety and security of buses, not bus lane enforcement. This results in little to no enforcement of the bus lane.

### Flower Street Bus-Only Lane

The Flower Street bus-only lane is peak-hour (evening peak only, as it is operational from 3-7pm), that runs for 1.8 miles on the one-way southbound street, from 7th Street to 23rd Street. This bus lane utilizes striping and signage as passive enforcement techniques, and receives heavy police enforcement that costs Metro approximately \$26,000 a day. No design solutions, such as inset parking, were used on this bus lane to reduce the frequency of conflicts. This dedicated enforcement unit started enforcing the lane in June and their contract was extended to March 2020.

## Bus Lane Management Practices

I also analyze the role of bus lane management for maintaining key functions of bus-only lanes, including on-time performance, bus operator security, bus safety and customer experience. This was conducted through a literature review and subject matter expert interviews with LA Metro, the Los Angeles Police Department, and the City of Los Angeles Department of Transportation. Additionally, I assess the effectiveness of different types of enforcement (active and passive techniques) and costs associated with these strategies, with a particular focus on Los Angeles. I compare strategies, directives, and budgets of enforcement on the two case study bus lanes. The study relies on budgets, memoranda, contracts, and other documentation related to Metro's contract with the Los Angeles Police Department, Long Beach Police Department, and Los Angeles Sheriff's Department. These documents were made available through Metro's Safety and Security department, and primarily focus on the New Blue Improvement Project, which funded the dedicated police unit on the Flower Street bus lane.

## Operator Experience

A short survey was used to assess the experience of operators on two bus-only lanes, the Wilshire Boulevard bus lane and Flower Street bus lane. Although discrete survey instruments were distributed to Wilshire and Flower bus lane operators, the surveys were identical except for the names of the Metro Lines and bus lanes mentioned. Questions focused on what types of conflicts are occurring in the bus-only lanes, how frequently they are occurring, and how they affect the experience of operators.

## ***Bus Operator Survey Design***

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The Wilshire Boulevard and Flower Street Bus Lane operator survey specifically focused on the following dimensions of the bus operator experience:

### **Use of the bus lane**

- If bus operators felt that the bus lane allowed for time savings and increased reliability of operations\*
- If bus operators use the bus lane, and if so, how frequently
- If they don't use the bus lane, what the key reasons are for not using the lane

### **Bus lane conflicts**

- If they do use the bus lane, what types of obstructions cause the most delay in the bus lane
- What types of obstructions are most commonly blocking the lane
- Specific locations of where these obstructions are occurring the most
- If there have been any changes in violations in the past month

### **Effect of conflicts on operator experience**

- How these obstructions affect a variety of dimensions of operations, including:
  - on-time performance,
  - their ability to take breaks,
  - their sense of physical security,
  - their perception of roadway safety, and,
  - the perceived effect on customer attitudes and behavior.

\*These questions were added after the first round of deployment, see previous footnote.

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## ***Characteristics of Study Participants***

Surveys were administered to a total of 77 bus operators, 46 of whom utilize the Wilshire Boulevard Bus-Only Lane (26 drive the Metro Rapid line 720 and 20 drive the Metro Local line 20) and 31 whom work the Flower Street Bus-Only Lane (J Line, also called the Line 950/910). All of the 77 bus operators who started the survey completed it. These surveys were taken during operators' regular break during the hours of 11:00 AM and 2:00 PM, between morning and afternoon shifts, at Divisions 13, 1, and 9, during three different visits in February 2020 (2/5 for Division 13, 2/24 for Division 1, and 2/26 for Division 9). The operators who completed the surveys were not required to do so, though those who did were compensated for 15 minutes of "regular straight time" at their working pay rate.

The surveyed operators had high levels of familiarity with their respective bus routes and with the bus lanes. Almost all respondents stated that they either very frequently or frequently used the bus lane. Of all surveyed operators, the BRT line 720 bus operators had worked this line most consistently. Metro 20 Line operators were the least consistent, the majority of them reported operating their buses in the lanes at least once a week, and many substantially more than that (See Figure 1). However, there is enough consistency between

the Wilshire Boulevard and Flower Street bus lane operators sampled to draw comparisons across these survey results.

## Safety and Security

Transportation agencies differentiate between safety and security. For the purpose of this study, I define safety and security the following ways:

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**Roadway safety** is defined as the ability for the bus operator to avoid collisions with other vehicles and non-motor-vehicle roadway users (i.e. pedestrians and bicyclists).

**Physical security** for an operator is defined as the ability to avoid altercations or incidences with customers that might lead to physical harm.

**Operational security** includes things like stressful working conditions, mandatory overtime, the inability to take scheduled breaks, and so on, all of which influence operational safety of the bus, and the wellbeing of operators themselves. Additionally, there are larger effects of poor operational or workplace security beyond the functioning of the bus. Operator security may influence the ability for Metro to retain operators, maintain schedules without cancellations, and address the shortage of bus operators.

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I analyze these dimensions of safety and security in the survey of operators, which allows for a nuanced analysis of safety and security from the perspective of bus operators. The empirical analysis focuses solely on roadway safety, as this is captured by LA Metro and is most directly related to the management and use of bus-only lanes.

### *Collision Incidence*

To analyze roadway safety, I rely on incidence reporting and statistics from the Metro's Service Planning Analysis (SPA) portal. Reporting included almost all incident types in the traffic collision class, with the exception of incidents related to mechanical issues.<sup>43 44</sup> I draw comparisons between pre- and post-installation periods for each bus lane.

Within LA Metro's collision reports, each incident includes a location, or the closest cross streets where the collision occurred. I parse out which collisions occurred at or near intersections in each bus lane, and which collisions occurred outside the bus lane. I assigned a dummy variable to these two groups, then run chi-squared tests for total collisions pre- and post- installation for both bus lanes. On Wilshire, I also look at individual collision types and run similar chi-squared

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<sup>43</sup> These classifications include the following collision types: bus hits vehicle; collision with fixed or stationary object; vehicle turns right in front of bus; turning right, other vehicle from rear; straight ahead, other vehicle from right; sideswipe, other vehicle passing other vehicle; bus pulling into zone, involved with moving vehicle; metro vehicle vs. bicycle; other vehicle in same direction of travel involved with rear of bus standing in zone; collision not otherwise classified.

<sup>44</sup> LA Metro uses the term accident, in relation to vehicle collisions. However, this terminology is being phased out in the transportation field.

tests for these individual types. This helps me determine if the presence of the bus lane is positively associated with total collisions as well as with reductions in certain types of collisions.

- For the Wilshire Boulevard bus lane, I pull eight years of data from two bus lines that operate on the bus lane, Wilshire Rapid and Local Lines, or 720 and 20. I look at four years before the majority of the bus lane’s installation in 2015 (2011-2014) and four years after its completion (2016-2019).<sup>45</sup>
- For the Flower Street bus lane, I had a much smaller time period to work with, as the bus lane had only been installed about 10 months before this study was conducted. I draw on eight months of data in the year prior to the Flower Street bus lane installation and eight months of the pilot period (June 2018 – January 2019 compared to June 2019 – January 2020).

I draw on bus incidence reports to see how operator’s perceptions of roadway safety compare to empirical data. I conduct before and after comparisons on both Flower Street and Wilshire Boulevard. For Wilshire Boulevard, I pull four years of data from two bus lines that run on the bus corridor (Wilshire Rapid and Local Lines, or 720 and 20). I compare data before the majority of the bus lane was installed (2011-2014) and four years after the bus lane was completed (2016-2019). I run chi-squared tests for total collisions pre- and post- installation for both bus lanes.<sup>46</sup>

## In Service On-Time Performance

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Bus operator performance is measured in two main ways, **on-time performance**, or schedule adherence, and **headway adherence**, or the coefficient of headway variation. On-time performance is defined as the consistency of service based on time tables or schedules. Headway adherence is defined by the consistency of spacing between buses on a route.

On-time performance is defined by LA Metro as a public transportation vehicle arriving at a time point (which are usually a sub-set of stops or stations) no more than one minute early or five minutes late. On-time performance is calculated below, where “services” refers to buses on a route that are “in service” or picking up and dropping passengers:

$$\text{On time performance} = \frac{\text{services on time}}{\text{total services}} \times 100\%$$

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<sup>45</sup> The largest segments of the Wilshire bus lane were installed in the spring and winter of 2015. However, a 1.8-mile segment was opened in 2013. For the purpose of my analysis, I just focus on 2015 as the “installation period.” I do not include 2015 in my analysis, due to a variety of factors – motorists often take time to adapt to new roadway regulations, thus this could have influenced the results, and there was extensive construction along Wilshire Boulevard in 2015 for the Purple Line Extension project. For more information, see “Wilshire BRT: Before and After Report” (2017)

<sup>46</sup> For p-values for total collisions and individual collision types, see Appendix E: Bus Lane Collision Incidence)

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On-time performance is measured by **timepoint**. Timepoints, in the context of bus service, are point on a bus line or route where the operator is scheduled to pass at a specified time (“Transit Capacity and Quality of Service Manual,” 2013). Often, agencies aggregate these data to individual lines or routes, by day type (weekend or weekday), by direction, and by other measures.

Headway adherence is considered a better measure of bus performance than on-time performance because it produces operating practices that are better for customer experience (“Elevated Standards for Bus Operations – Scheduling and Dispatching,” 2019). However, LA Metro does not use headway adherence as a performance metric. I therefore use on-time performance in this analysis.<sup>47</sup>

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In Service On-Time Performance (OTP) is compiled in a variety of reports, for each line and route, by day type (weekday or weekend). This research focuses on the OTP of the following Metro service: Metro Line 720 and Metro Line 20 (Rapid and Local service on the Wilshire bus lane), Metro J Line and Line 460 (on the Flower Street bus lane). The 720 and 20 are the only Metro services on Wilshire Boulevard. Although other Metro lines run on Flower Street, the J Line and 460 run most consistently, as well as on the whole length of the bus lane.

I compare OTP before and after both bus lanes were installed. For the Wilshire Boulevard bus lane, I compare OTP for the Metro 720 and 20 lines four years before installation (2011-2014) and four years after the majority of the bus lane’s installation (2016-2019). For the Flower Street bus lane, I compare OTP for the Metro J Line and Line 460 from June 1, 2018-January 31, 2019 and June 1, 2019-January 31, 2019. I look at OTP by timepoint, and selectively sample timepoints that fall both on and off the case study bus lanes.<sup>48</sup> I then aggregate individual timepoints to see OTP averages both on and off the bus lane.

#### Wilshire BRT: Before and After Study, 2017

An analysis of on-time performance of the Wilshire bus lane in a previous study in 2017 led to mixed results (“Wilshire BRT: Before and After Study,” 2017). The study found that the number of late arrivals were reduced, but this was only along segments of the corridor where there was no construction of the Purple Line Extension. This construction project heavily influenced results

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<sup>47</sup> For a discussion of traditional performance metrics, and strengths and limitations of these, see Cevallos’ paper entitled “Transit Service Reliability: Analyzing Automatic Vehicle Location (AVL) Data for On-Time Performance and Identifying Conditions Leading to Service Degradation” (2016) and research by Sam Schwartz Engineering entitled “Elevated Standards for Bus Operations – Scheduling and Dispatching” (2019)

<sup>48</sup> I use ISOTP timepoints only within LA Metro’s In Service On Time Performance Reporting. I sample based on various conditions. For example, I did not sample time points that fell on the bus lane but directly followed a segment of the corridor without a bus lane (such as Wilshire/Westwood in the Eastbound direction of the 20). I also did not sample time points that fell off the bus lane but were directly preceded by a long bus lane segment. For detailed tables by line and direction, see Appendix F: On-Time Performance Analysis



and brought down on-time performance (OTP), thus, timepoints where construction was occurring were left out of the analysis. Overall, the bus lane improved OTP for Eastbound service, but Westbound service OTP declined. The study largely attributes this decline to traffic conditions, breaks in the bus lane, and intersections (such as Wilshire/Westwood) with high volumes of right-turning traffic and pedestrians (“Wilshire BRT,” 2017, p.17).

This study compared a two-week “free-running pilot” in 2016 to regular service performance in 2015. During this pilot, bus operators were asked to operate without adhering to the schedule. If an operator came to a timepoint early, they were not required to wait until the scheduled departure time. The pilot was an attempt to determine how much the bus lane could reduce late arrivals. However, even within this situation, where operators did not have to wait at timepoints to stay on schedule, the number of late arrivals increased in some areas. Windfall effects from segments without a bus lane (Beverly Hills) and congestion through Westwood and at the I-405 freeway ramps caused increase in late arrivals during the PM peak (between 8% and 21% change). In other segments and time periods, the percent of late arrivals did decrease.

There are some differences between this analysis and my own. The study team compared this free-running pilot to regular service in 2015. However, the bus lane was installed in 2015, thus, this does not provide a true pre- and post-installation analysis. The authors state that “the schedule for Metro Rapid Line 720 was not adjusted to reflect implementation of the bus lanes and impacts due to Metro Purple Line construction” at the time of this study (“Wilshire BRT,” 2017, p. 26). However, it is not clear why LA Metro had not adjusted this schedule, and if it had been changed after the study had been completed. One challenge of OTP as a metric of a bus lane’s effectiveness is that so many factors can influence its performance—such as outdated schedules and different operating procedures by each operator and division.

OTP requires operators to run on schedule, not run fast. Thus, even if a bus lane is providing time savings, and operator is required (under normal operations) to wait at a timepoint to get back on schedule. Thus, OTP does not always translate to fast and reliable service from the viewpoint of the customer (“Elevated Standards for Bus Operations –Scheduling and Dispatching,” 2019; “Transit Capacity and Quality of Service Manual,” 2013). If a bus line increases average operating speeds, OTP can simply increase dwell time, or the time the bus is sitting at a bus stop, as well as reduce a bus stop’s capacity (“Transit Capacity,” 2013). Additionally, OTP can lead to inconsistent headways on congested streets, as schedules do not often reflect existing conditions. For example, from a headway management perspective, it might make sense for some buses to run early and not pick up customers at every stop in order to keep consistent spacing between buses. This is a common strategy within agencies that use headway adherence as a metric. Some agencies even have someone in the field dynamically dispatching buses, which means someone is tracking buses along a line or route and modifying their departure times and wait intervals at timepoints in real-time. This can help agencies maintain headway adherence (“Elevated Standards,” 2019).

# Findings

My findings fall under four broad sections:

- bus lane management practices,
- bus operator experience,
- collision incidence, and lastly,
- on-time performance.

These eight key findings are listed below:

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## Bus Lane Management Practices

**Finding 1.** Existing passive enforcement techniques and design solutions are not sufficient for managing mixed-use bus lanes in Los Angeles.

**Finding 2.** Dedicated bus lane enforcement is effective but expensive. To create a scalable option, Metro would have to automate enforcement on bus lanes.

## Operator Experience

**Finding 3.** Even when unenforced, bus lanes provide a benefit. However, enforcement is tied to positive outcomes for the bus lane.

**Finding 4.** Conflicts in the bus lane are similar across unenforced and enforced bus lanes, and the greatest amount of delay is due primarily to parked private cars, Uber/Lyft or taxis idling in the lane, and private vehicles illegally driving in the lane.

**Finding 5.** Operators view certain intersections as hot spots of vehicle intrusions.

**Finding 6.** Most operators perceive that vehicle intrusions reduce roadway safety, causing them to have to weave in and out of traffic, increasing their stress and the likelihood of collision.

## Collision Incidence

**Finding 7.** Overall, traffic-related collisions have declined since the installment of the Wilshire Boulevard bus lane. Of all collision types, the only types that were significantly reduced by the Wilshire Boulevard bus lane were from vehicles turning right into the bus.

## On-time Performance

**Finding 8.** There are mixed effects of both bus lanes on on-time performance.

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## Bus Lane Management Practices

Finding 1. Passive enforcement was never supposed to be a standalone strategy for managing the Wilshire Boulevard bus lane, and is not a sufficient for managing mixed-use bus lanes in Los Angeles County.

The Wilshire Boulevard bus lane is primarily passively enforced through striping and signage. LA Metro has a contract with Los Angeles Police Department (LAPD) and Los Angeles Sheriff's Department (LASD) to serve as the contracted transit police for the system. Metro had primarily relied on "vehicle patrol" officers contracted through LAPD, whose primary directive is to ensure safety and security on Metro's bus lines, and not keep the bus lane clear. Vehicle patrol officers issue tickets for parking or moving violations, but in most instances, this type of enforcement is infrequent. Wilshire Boulevard experiences rampant violations of vehicles illegally parking and driving in the lane.

Historically, enforcement was proposed for the Wilshire bus lane, and was even used and budgeted for in an early pilot bus lane on Wilshire Boulevard (City Council File 03-2337-S1, 2007). Planning first began for the Wilshire BRT project in the early 2000's. LA Metro, in partnership with LADOT, installed a temporary one-mile pilot bus lane to serve as a demonstration project (much like the Flower Street project). This bus lane was proposed as a six-month pilot, and was installed in March 2004 (Stroup, 2007). It was made permanent by an LA City council decision at the end of the pilot, but was removed in 2007 in the preparation for the development of the full Wilshire BRT project. Based on a city council document the bus lane pilot project had a \$60,000 enforcement budget for the six-month pilot period.<sup>49</sup> This budget went to fund a Wilshire Boulevard Tiger Team.<sup>50</sup> LADOT deployed tow trucks at the start of the bus lane hours in a Tiger Team that cleared the lane in a highly-visible fashion that encouraged motorists to not park in bus-only lanes. However, this was not sustained after the first few months of the Wilshire bus lane. As planning continued for the Wilshire bus lane, enforcement was seen as a critical component of successful implementation. The LADOT General Manager, Gloria Jeff, wrote in a memo to the LA City Council that a peak period end-to-end bus lane would require:

*... an aggressive level of traffic enforcement to maintain bus travel time and speed benefits. This would mean active enforcement of prohibitions against stopping and parking and driving of non-transit vehicles in the bus lanes. Ticketing and towing of stopped and parked vehicles could be handled by LADOT's Wilshire Boulevard Tiger Team over the long term, but additional Traffic Officers would be needed during the first 3-6 months of operation to mount an aggressive enforcement campaign and change driving patterns (City Council File 03-2337-S1, 2007, p. 5).*

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<sup>49</sup> This bus lane enforcement was funded through an initiative through the former Mayor's Office, see Guccione, 2013.

<sup>50</sup> See Section on Dedicated enforcement and "blitzes" for a full description of this strategy.

Despite this recommendation, a dedicated towing team was used for only the first few months of its opening. Almost immediately, the Wilshire bus lane gained attention as a site of unchecked motorist violations and late buses (Linton, 2015). In 2017, a study commissioned by LA Metro found that almost half of bus operators wanted to see more monitoring and enforcement of the bus lane, and the other half wanted a redesign of the bus lane (“Wilshire BRT: Before and After Report,” 2017). Lane intrusions by motorists, bicycles, and commercial vehicles were the top problem cited by operators. The report also recommended redesigning the bus lane to be offset from the curb at certain intersections and segments with high vehicle and pedestrian traffic and high volumes of right turning vehicles, such as at Westwood Boulevard (“Wilshire BRT: Before and After Report,” 2017).

Finding 2. Dedicated enforcement is effective but expensive. To create a scalable option, LA Metro would automate enforcement. As an intermediary measure, LA Metro should partner with LA City to conduct parking enforcement blitzes in bus lane segments with high violation rates.

Like the Wilshire Boulevard bus lane, the Flower Street project was passively enforced with striping and signage. In addition to fixed-post signage, the bus-only lane utilized existing electronic signage, both on gantries and on variable message signs. However, unlike Wilshire, The Flower Street bus lane received active enforcement in tandem with the Figueroa Boulevard bus lane (S. Walker, personal communication, July 18, 2019).<sup>51</sup> This enforcement strategy was tied to the New Blue Improvement Project, a major capital improvement project commenced in 2019 for the A Line (the new name for the old Blue Line light-rail line) which runs between Downtown Los Angeles and Long Beach (“New Blue Improvements Project,” n.d.). LA Metro built off this existing LAPD/LASD and Long Beach PD contracts and funded additional dedicated enforcement through a carve out of the New Blue Improvements Project funding (S. Walker, personal communication, July 18, 2019). The Flower Street bus-only lane was installed to mitigate the effect of the service disruption for tens of thousands of Expo and Blue Line<sup>52</sup> commuters by improving throughput for the bus bridges between three downtown rail stations (“Flower St PM Peak Bus Only Lane Pilot,” 2019). This bus lane received dedicated enforcement by the LAPD during the rail station closures between June and November of 2019,<sup>53</sup> while Figueroa Street received enforcement as the bus bridges traveled southbound on that street (S. Walker, personal communication, July 18, 2019).

This enforcement strategy was a unique opportunity for LA Metro to test a new way to manage bus-only lanes. This enforcement structure was seen as the best option for the New Blue project since Metro already had an existing contract with LAPD/LASD, and because peace officers are

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<sup>51</sup> See Appendix B: Existing and Planned Bus Lanes in Los Angeles County information on the Figueroa Boulevard bus lane.

<sup>52</sup> Renamed the E and A Line, respectively, after this project was completed. For more information on LA Metro’s change to line letters, see [metro.net/projects/line-letters/](https://www.metro.net/projects/line-letters/)

<sup>53</sup> The enforcement on Flower and Figueroa bus lanes was later extended to March 2020. The E Line stations reopened in September, and the A Line reopened in November. However, the New Blue Improvement contract remained open with LAPD/LASD as the Willowbrook/Rosa Parks station was still underway. For more information go to: <https://www.metro.net/projects/blue-line-willowbrook/>

able to enforce both moving and parking violations (S. Walker, personal communication, July 18, 2019). If Metro were to partner with LADOT for a dedicated team of parking enforcers to monitor the lane, only parking violations could have been cited. LADOT had the authority to enforce parking violations on the Flower Street bus only lane, however, since there was no dedicated unit for the Flower or Figueroa Street bus lanes, there were only two parking violations issued during the pilot period by LADOT parking officers (N. Borgman, personal communication, August 21, 2019).

There were three types of police detail, police in vehicles, on motorcycles, and stationary guards, who would provide security, wayfinding, and support Metro staff at major transit hubs along the corridors (S. Walker, personal communication, July 18, 2020).<sup>54</sup> Police on motorcycles were particularly useful for bus lane enforcement, as they were able to weave through traffic, communicate better with passersby, and more quickly circulate than police cars. They were also highly visible and could discourage motorists from driving in the lane.

**Figure 15** provides counts of lane intrusions and moving and parking violations in the bus-only lanes from between June 23rd 2019 and January 25th 2020.<sup>55</sup> Officers did not start handing out citations until the third week of June, as the first few weeks were used to educate roadway users on the bus-only lane restrictions. The most common law enforcement strategy was a vehicle citation, followed by a verbal warning, a written warning and then a forced ejection from the lane.

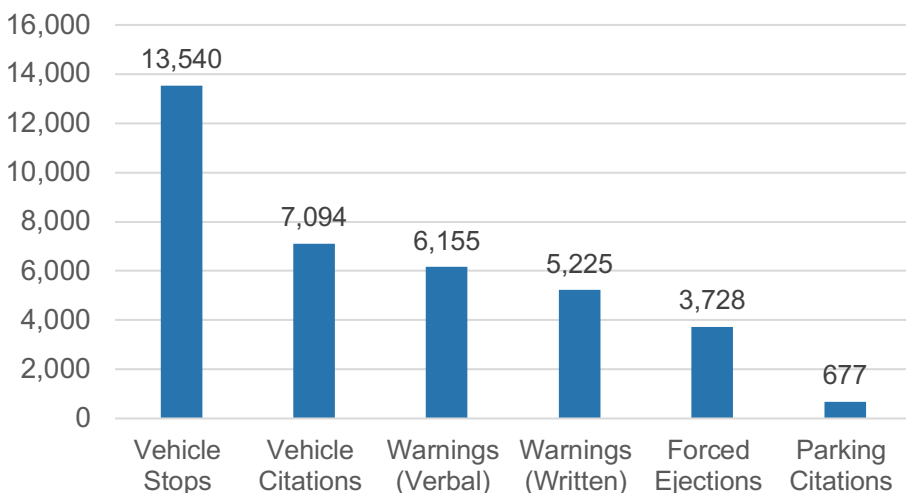
The LAPD were operating under a “proactive enforcement approach” versus a “zero-tolerance approach” where the primary objective was to ensure mobility of the bus lane. Thus, officers would attempt to clear the lane as quickly as possible. Parked motorists, for example in the lane, would be directed to clear the lane, and would only receive a verbal warning if it was a first offense. Officers would only issue a parking citation and tow if no motorist was present. Thus, the low counts of parking citations are more of a product of the enforcement directive than the on-the-ground reality. LAPD officers were also directed to target frequent offenders of the bus lane, such as Uber/Lyft vehicles and taxis, which often idled or drove in the lane. The high counts of vehicle stops (or police pulling over a vehicle) are most likely due to officers stopping to tell a parked motorist or Uber/Lyft idling in the lane to depart the lane (S. Walker, personal communication, July 18, 2019).

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<sup>54</sup> LAPD officers worked in nine-hour shifts, in the field from 5am-9pm and from 3pm-7pm. In the morning, LAPD would focus on Figueroa Street, since the Flower Street bus-only lane was not running, and in the afternoon peak they would loop between Flower and Figueroa Street, enforcing both continuously. Police also worked on the weekend, but as the Flower Street bus-only lane was only operating on weekdays, they focused only on Figueroa Street. LAPD officers worked in split shifts, in the field from 5am-9pm and from 3pm-7pm.

<sup>55</sup> Enforcement was removed from the bus lane in March 2020 due to reduced traffic flows during COVID-19.

**Figure 15:** Counts of enforcement events on the Flower Street and Figueroa Boulevard bus lanes (June 2019–January 2020)



*LAPD Recap from bus-only lane enforcement during the New Blue Improvement Project from June 2019–January 2020 (Source: author-made figure with data provided through LA Metro/LAPD)*

Metro paid \$75,000 at the start of the pilot to install striping and signage that constitute the passive enforcement. In addition to fixed-post signage, the bus-only lane utilized existing electronic signage, both on gantries and on variable message signs. The largest costs associated with the bus-only lane were from LAPD/LASD active enforcement of the lanes. For the Flower and Figueroa Street bus lane enforcement, officers were paid in overtime shifts, dedicated to bus-only lane enforcement. This required Metro to pay overtime hourly rates, which drove up costs. Costs for the dedicated police unit were around \$26,000 a day (see **Table 2**). The bus lane enforcement costs were bundled with costs for police at major transit hubs, providing wayfinding and helping customers navigate the station shutdowns and bus bridges (S. Walker, personal communication, July 18, 2019). This inflated the budget considerably.

When compared to costs of other forms of active enforcement, such as Tiger Teams or automated camera enforcement, the dedicated LAPD unit costs are extremely high (see **Table 2**). If LA Metro tried to scale the Flower Street enforcement model system-wide, it would cost the agency a back-of-the envelope estimate of \$37.4 million per year.<sup>56</sup> Tiger Teams, by comparison, would cost around \$3.2 million, due to lower labor expenses.<sup>57</sup> In comparison, San Francisco deployed automated camera enforcement along 22 miles of bus lanes, called the Transit Only Lane Enforcement (TOLE) program. This is commensurate in size and scope to what LA Metro could implement across its 27 bus lane miles. Capital costs were around \$6.3 million, but yearly operating costs are much lower at \$330,00 per year for staffing and video maintenance (“San Francisco TOLE Evaluation Report,” 2015).

<sup>56</sup> Estimated based off enforcement costs of the New Blue Improvements Project.

<sup>57</sup> Estimated based off enforcement costs of the Wilshire Bus Lane Demonstration in 2006.

Although effective on the Flower and Figueroa bus lanes, using a dedicated police unit across all of LA Metro’s mixed-use bus lanes is far from economical. Automated enforcement can be scaled to a large network of bus lanes relatively cheaply. As a stopgap measure, LA Metro could partner with LADOT to deploy Tiger Teams along its bus lanes, or at least in segments with high violation rates.

**Table 2:** Comparison of bus lane active enforcement costs, modeled for scaling system-wide

TYPE	SITE	MILEAGE ENFORCED	PER DAY COST	ANNUAL OPERATING COST	CAPITAL COSTS	ESTIMATED ANNUAL COST FOR LA METRO’S ENTIRE BUS NETWORK
<b>Dedicated police unit</b>	Flower & Figueroa Street	6.5 miles	\$26,100	\$9 million	n/a	\$37.4 million
<b>Intermittent parking enforcement (Tiger Team)</b>	Wilshire Boulevard (2004-2007 temporary pilot)	1 mile	\$350	\$120,000	n/a	\$3.2 million
<b>Automated enforcement program (San Francisco)</b>	City-wide	22 miles	~\$900	\$330,000	\$6.3 million (\$9,500 per camera)	n/a

*Costs modeled off 27 miles of mixed-use bus lanes in LA County. These costs are estimates based on LAPD’s contract with LA Metro, and San Francisco’s Transit Only Lane Enforcement Program, or TOLE program (Source: data provided through correspondence with LA Metro/LAPD, 2015 San Francisco Transit Only Lane Enforcement Evaluation Report)*

## Bus Operator Experience

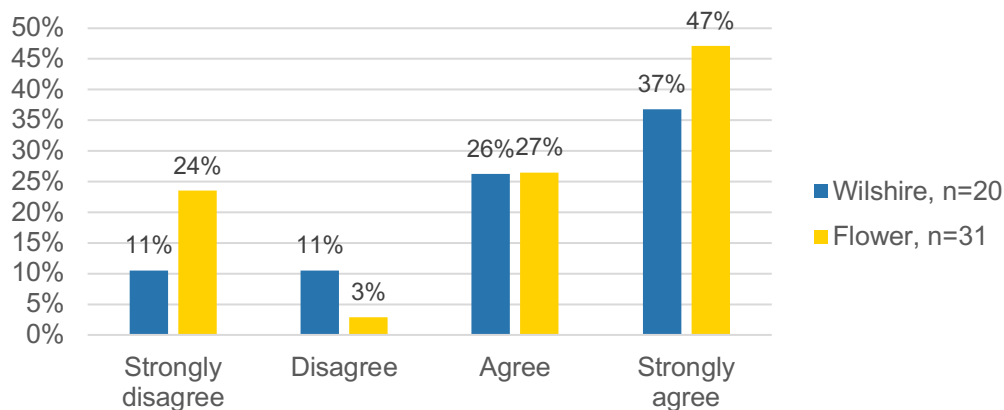
Finding 3. Even when unenforced, bus lanes provide a benefit. However, enforcement is tied to positive outcomes for the bus lane.

A question that I sought to answer in this study was whether unenforced bus lanes improve bus operations. I determined this in two ways – whether bus operators consistently used the lane, and whether operators found that it allowed for time savings (by increasing travel speeds) and increased reliability of bus operations. I found that Wilshire and Flower operators largely use the bus lanes, despite delay and conflicts in the lane. Ninety percent of operators on Flower Street, and 94 percent of operators on Wilshire Boulevard reported very frequently or frequently using

the bus lane. This suggests that either operators are trained to use the lane regardless of benefit, or that bus operators find benefit from the bus lane.

Based on the survey results, I find that on both the Wilshire Boulevard and Flower Street bus lanes, operators largely agree that the lane increase travel speed and reliability. This suggests that operators are using the lane due to the benefit it entails. Although it is not possible to draw a causal relationship between enforcement and bus travel speed and reliability, enforcement is tied to positive outcomes on Flower Street. On Flower Street, where there is enforcement in the form of a dedicated police unit, operators report greater reliability and travel time outcomes than on Wilshire Boulevard. Seventy-four percent of operators on Flower Street agree or strongly agree that the bus lane improves travel speeds, compared to 63 percent on Wilshire Boulevard (See **Figure 16**). According to operators, Flower Street, with dedicated enforcement, increases travel speeds more than the Wilshire Boulevard bus lane.

**Figure 16:** Bus operator response to “the bus lane increases travel speed”

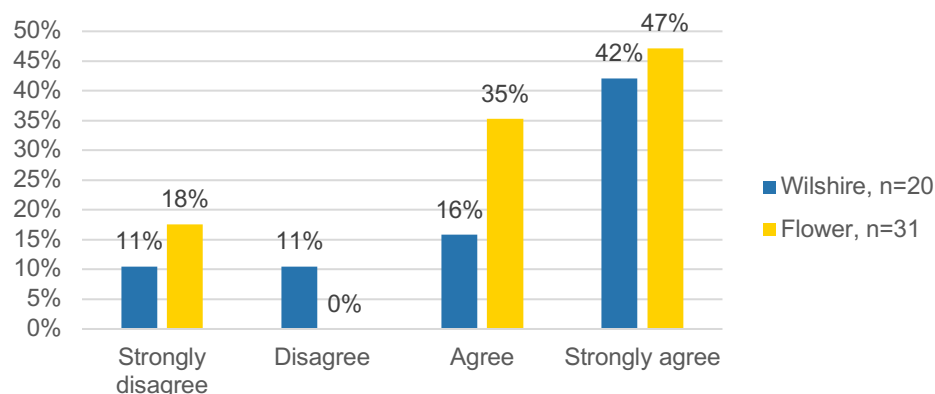


*Operators were asked the following question: thinking about your experience using the [Wilshire/Flower Street] bus lane, how much do you agree or disagree with the following statements? – “the bus lane increases bus travel speeds” (Source: Bus operator surveys conducted by the author)*

There is an even greater difference in relation to reliability between the bus lanes. Eighty-two percent of operators on Flower Street, and 58 percent of operators on Wilshire Boulevard, strongly agree or agree that the bus lane allows for improved reliability (See **Figure 17**). This could suggest that dedicated active enforcement allow for more consistent conditions in the Flower Street Bus Lane. The Wilshire bus lane, dependent on congestion and higher violation levels, could create less reliable conditions for bus operations.



**Figure 17:** Bus operator response to "the bus lane increases reliability"



*Operators were asked the following question: thinking about your experience using the [Wilshire/Flower Street] bus lane, how much do you agree or disagree with the following statements? – “the bus lane increases the reliability of bus on-time performance” (Source: bus operator surveys conducted by the author)*

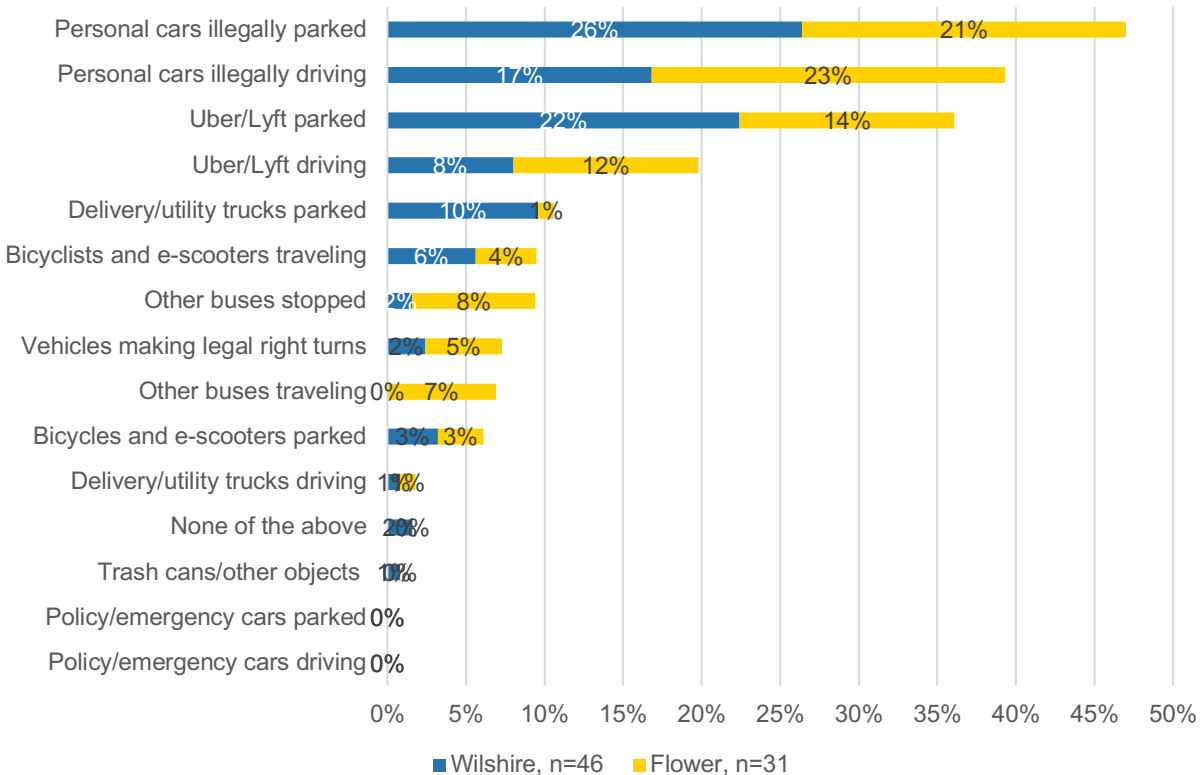
These findings suggest that the presence of bus lanes on Flower Street and Wilshire Boulevard improve the travel time and reliability of bus operations. However, the higher proportion of operators who agree or strongly agree that the bus lane increases these two factors indicates that the Flower Street bus lane is a more effective bus lane.<sup>58</sup> Although this case study cannot determine causation, there is a positive correlation between enforcement and greater travel speeds and reliability.

Finding 4. Conflicts in the bus lane are similar across unenforced and enforced bus lanes, and the greatest amount of delay is due primarily to parked private cars, Uber/Lyft idling in the lane, and private vehicles illegally driving in the lane.

As seen in **Figure 18**, bus operators were asked to rank the top three conflicts that most affect their ability to use the lane. The most common answer for both the Flower Street and Wilshire Boulevard was parked vehicles (approximately one-quarter of all operators), followed by motorists illegally driving in the lane, and Uber/Lyft vehicles and taxis stopped in the bus lane. This question asks about their ability to use the lane, not frequency of conflicts (the latter is depicted in **Figure 19**). Although other types of conflicts occur more frequently, they do not slow down the bus lane as much as a parked vehicle.

<sup>58</sup> This question was not asked into after the first round of survey disbursement to operators – thus, all of the operators of Metro line 720 did not weigh in on this question.

**Figure 18:** Operators' ranking of violations affecting their ability to use the lane



*Operators were asked the following question: Please select the three things that affect your ability to use the [Wilshire Boulevard/Flower Street] bus lane the most.*

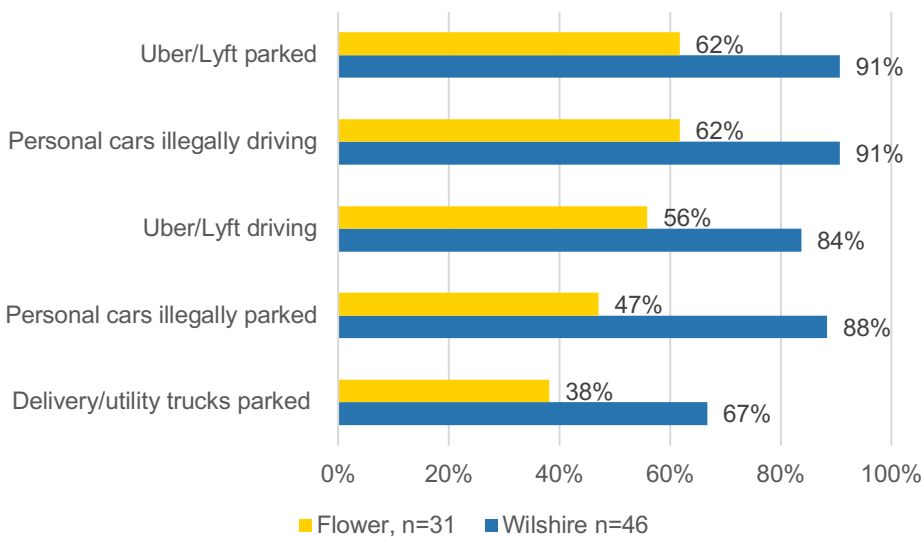
When a motorist is parked in the bus lane, a bus operator generally has to depart the bus lane and re-enter the lane in order to maneuver around the vehicle. On a congested street, this can require the bus to wait in a queue to enter the general traffic lane. Based on anecdotal reporting from LAPD officers that work on Flower Street, parked cars take on average 30 minutes to one hour to tow out of the lane (LAPD officer, personal communication, July 2019). The Flower Street bus lane had approximately one bus every minute traveling on the lane, thus, one parked vehicle could delay 30-60 buses (“LA Metro Informational Report N2019-0663 Flower Street Bus Lane Evaluation,” 2019) With these two factors combined, parking violations have outsized effects on bus lane performance. Without enforcement, such as the case on Wilshire Boulevard, these effects are exacerbated; a vehicle might remain parked in the lane for hours, affecting the performance of many buses. A bus operator might have to navigate around the same parked vehicle multiple times on their shift.

Although results are mostly consistent across both bus lanes, there are some discrepancies in operators' perception top violations across the bus lanes. After parked vehicles, on Flower Street, motorists driving in the bus lane are seen as causing more delay. In contrast, on Wilshire Boulevard, Uber/Lyft and taxis are a bigger cause of delay. This may be due to the differences in activity levels across the lanes. For example, the Wilshire bus lane passes through multiple tourism and entertainment centers, whereas Flower Street serves primarily commuter traffic

traveling out of Downtown. This reflects the causes of delay indicated in each lane (Uber/Lyft and taxis stopped on Wilshire, motorists driving on Flower bus lane). Delivery vehicles parked in the bus lane were also a commonly cited problem by operators that work Wilshire Boulevard, and not a problem on Flower Street. This may be due to fewer loading zones along the Flower bus lane compared to Wilshire.

Across both bus lanes, trash cans, parked police vehicles, and delivery vehicles and police vehicles driving in the bus lane are not seen as major issues affecting operator’s ability to use the lane.

**Figure 19:** Selection of the top five bus lane conflict types operators state are “always causing delay”



*Operators were asked the following question: In your experience, how often do each of the items below cause delay in the [Wilshire Boulevard/Flower Street] bus lane? (Source: bus operator surveys conducted by the author)*

Although ranked lower, some types are obstructions are much bigger problems on Wilshire, such as parked delivery vehicles, vehicles making legal right turns, and people riding bicycles and e-scooters in the lane. Additionally, there are many more obstructions in the category of “never” blocking the lane on Flower – such as police cars driving or parking in the lane, as well as trash cans or other objects blocking the lane. When looking across both bus lanes, personal cars illegally driving is one of the largest issues. Then Uber/Lyft idling or parked in the bus lane, driving, and then delivery/utility trucks and personal cars illegally parked.

On average, 84 percent of surveyed bus operators stated that the five most common vehicle intrusions (See **Figure 19**) were always causing delay on Wilshire. In comparison, on average 53 percent of surveyed bus operators on Flower stated that these top five vehicle intrusions were always causing delay. This cumulative difference is most likely a product of enforcement on Flower Street.

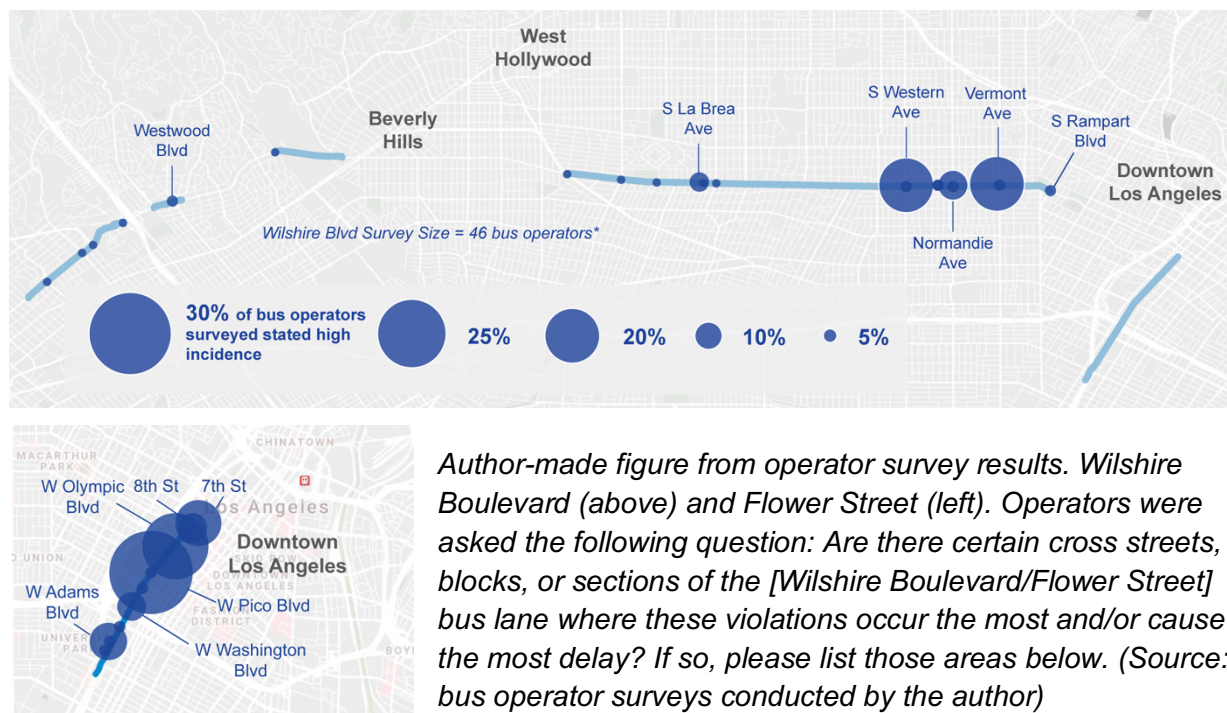
Finding 5. Operators view certain intersections as hot spots of vehicle intrusions.

Operators were asked to answer an open-ended question about whether there were certain cross streets, blocks or sections of the bus lanes where these violations occurred the most or caused the most delay. Surveyed operators largely listed the same intersections:

- Vermont Avenue (20% of operators),
- Western Avenue (20% of operators), and
- Normandie Avenue (11% of operators).

I consider these intersections to be vehicle intrusion hotspots. All of these hotspots are located in one-mile section of the bus lane, in the Koreatown neighborhood, a high-density mixed-use neighborhood near Downtown Los Angeles (see **Figure 20**). This segment of the bus way experiences high levels of congestion. Additionally, all of these intersections are access points to heavily trafficked rail transit stations, and are major entertainment centers.<sup>59</sup>

**Figure 20:** Hotspots of bus lane violations on case study lanes



Similar to Wilshire Boulevard, the majority of operators who work Flower Street largely cite three intersections where violations occur the most. The top hot spots cited include:

- Pico Boulevard (29% of operators)
- Olympic Boulevard (23% of operators), and
- 7th Street (16% of operators).

<sup>59</sup> Wilshire/Vermont is a heavy rail station serving the B and D Line, formerly called the Red and Purple Line. Wilshire/Western and Wilshire/Normandie are both heavy rail stations for D Line. For more information on LA Metro's change to line letters, see [metro.net/projects/line-letters/](http://metro.net/projects/line-letters/)

Since the Flower Street bus lane is only 1.8 miles in length, more operators answered the same intersections than the Wilshire Boulevard bus lane (which is 7.7 miles in length, or 15.4 lane miles). Like Wilshire, these intersections are all in heavily congested sections of the bus lane, next to transit hubs and entertainment centers—on Flower, Pico and Olympic access LA Live, and 7<sup>th</sup> Street serves the 7<sup>th</sup> Street/Metro Center rail station.

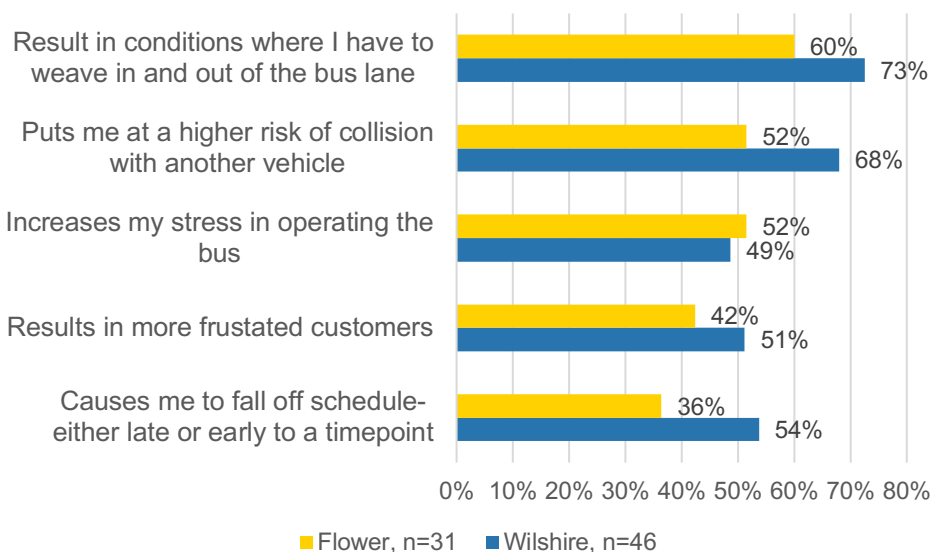
Increasing the priority in these hotspots, either through a design treatment or through heightened enforcement, would most likely have an outsized effect on the functioning of both of these bus lanes.

Finding 6. Most operators perceive that vehicle intrusions reduce roadway safety, causing them to have to weave in and out of traffic, increasing their stress and the likelihood of collision.

When queried, more than half of all surveyed bus operators indicated that common bus lane violations force them to weave in and out of traffic and put them at a higher risk of collision (see **Figure 21**).

- On Wilshire, 73 percent of operators strongly agree that bus lane intrusions cause them to weave in and out of traffic, and 68 percent strongly agree list that this puts them at a higher risk of collision.
- On Flower, 60 percent of operators strongly agree that bus lane intrusions cause them to weave in and out of traffic, and 52 percent strongly agree list that this puts them at a higher risk of collision.

**Figure 21:** Top five ways that conflict in the bus lane effect operator safety and performance



*Operators who responded that they “strongly agree” to the following question: Thinking about those top three things that affect your experience operating a bus in Wilshire Boulevard [Flower Street] bus lanes, how much do you agree or disagree with the following statements? (Source: bus operator surveys conducted by the author)*

Operators also perceived, to a lesser extent, that bus lane violations reduced their workplace or operational security. Around half of operators stated that bus lane violations increase their stress and reduce their on-time performance. Lastly, around half of operators also stated that violations cause more passengers to be dissatisfied with bus service. Across almost all of these measures, Wilshire Boulevard is lower-performing than Flower Street. The only exception is the question related to increasing stress. Fifty-two percent Flower Street operators reported said they strongly agree that bus lane violations increase their stress in operating the bus. Operators on Flower Street overall perceive greater safety and on-time performance, most likely as a result of fewer conflicts in the bus lane.

## Collision Incidence

**Finding 7.** Overall, traffic-related collisions have declined since the installment of the Wilshire Boulevard bus lane. Of all collision types, the only types that were significantly reduced by the Wilshire Boulevard bus lane were from vehicles turning right into the bus.

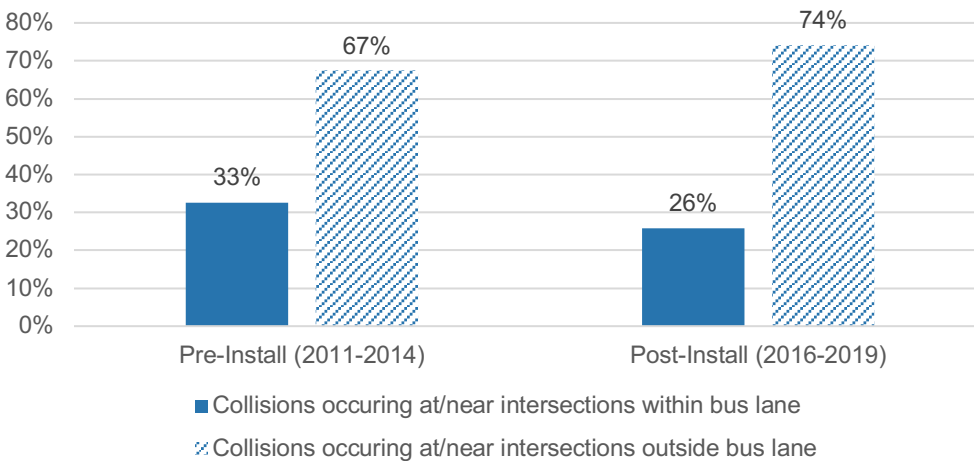
I draw on bus incidence reports to see how operator's perceptions of roadway safety compare to empirical data. Due to the shorter timespan to draw on, I do not find a result on Flower Street. Collisions increased after the installation of the bus lane, but this is not statistically significant.

However, there was a large decrease in bus collisions after the installation of the Wilshire bus lane. This decrease largely occurred along intersections within the Wilshire bus lane. In absolute terms, collisions within the bus lane sections declined by 31 percent. Proportionally, collisions outside of the Wilshire bus lane declined by a smaller share, only 4 percent. Before the bus lane was installed, 33 percent of collisions occurred at intersections where the bus lane would be located. After the bus lane was installed, only 26 percent of collisions occurred in the bus lane (see **Figure 22**). Although many factors could contribute to this decline, including new operating practices or technology that improve roadway safety, the chi-square tests reveal that this decline within the Wilshire bus lane is statistically significant ( $p < .05$ ).<sup>60</sup> These results are suggestion, but not definitive with respect to causation. However, there is a positive correlation between the presence of the Wilshire bus lane and improved roadway safety.

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<sup>60</sup> See comparison tables of collision incidences (across bus lanes, and across time periods), collision types and p-values in Appendix E: Bus Lane Collision Incidence

**Figure 22:** Pre- and Post- Installation Comparison of Collisions on Wilshire Rapid and Local (Metro Line 720 and 20)



*Author-made figure based on collision incidence reporting provided by LA Metro’s Service Performance Analysis (SPA) portal*

With eight years of data from Wilshire Boulevard, I was able to drill into a bit more detail and explore changes in specific collision types. Of all collision types, the only types that are significantly reduced are two different collision classes that relate to vehicles turning right into the bus (see **Figure 23**).

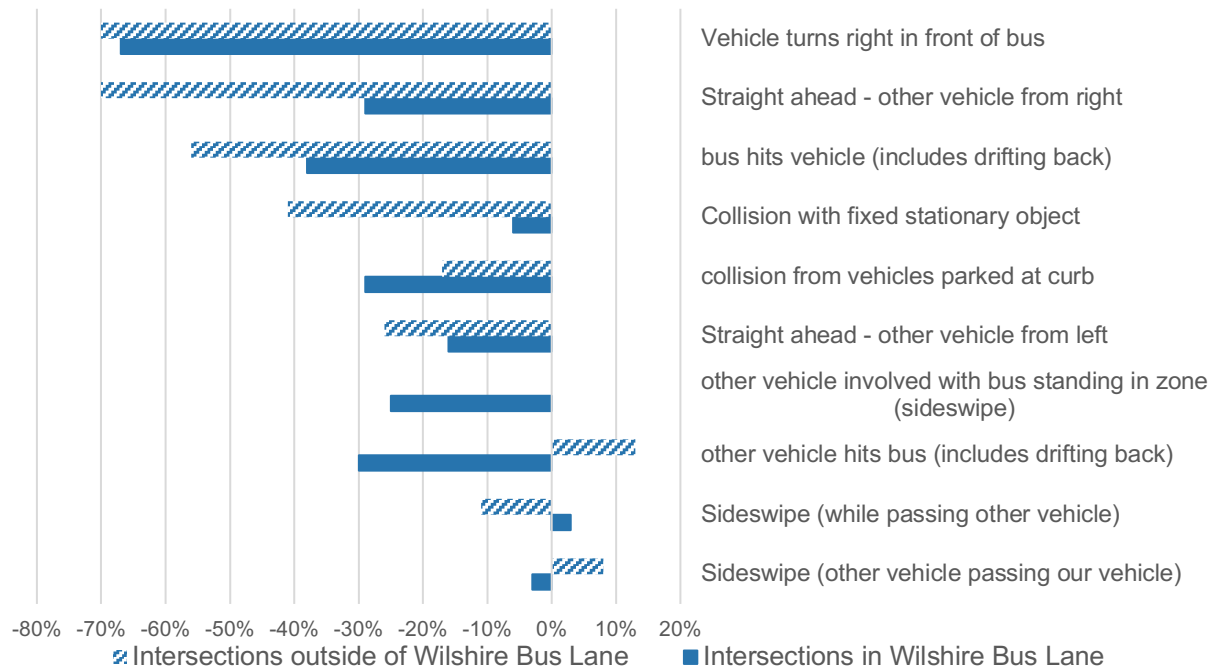
These two collision classes are:

- Collisions due to a vehicle turning right in front of the bus (a 70% decline in the bus lane, and a 67% decline on intersections outside the bus lane)
- Collision due to a vehicle on the right hitting the bus straight on (also a 70% reduction in the bus lane, and a 29% decline on intersections outside the bus lane)

This is most likely related to the physical design of the bus lane, where the dedicated curbside lane reduces the likelihood of a vehicle merging into the bus from the right, and thus the chance of right-side collision incidence.

I did not observe a statistically significant change in any other collision types. However, it is interesting to see that the only collision type that was higher in the bus lane, compared to outside the bus lane, is from buses crashing into vehicles parked at the curb. Although untested, this might be minimized if the bus lane were more actively enforced.

**Figure 23:** Percent Change in Incidence Levels by the Top Ten Collision Types from Before and After the Wilshire Bus Lane’s Installation



*Author-made figure based on collision incidence reporting provided by LA Metro’s Service Performance Analysis (SPA) portal*

The incidence rate of bus/bike collisions is extremely low on both bus lanes, in line with the literature on shared bus/bike lanes or SBBLs (Kosinski et al., 2017; Hillsman et al., 2012). On Wilshire Boulevard, there were only four reported bike/bus collisions in the four years prior to the bus lane’s installation, and during the four years after, there were only three collisions. This is not a statistically significant reduction; however, it is helpful to know that the Wilshire bus lane seems to be relatively safe environment for bikes. On Flower Street, I see similar results. There was only one bike/bus collision on the bus lane after its installation, and none prior.<sup>61</sup> Based on these results alone, bike/bus collisions do not appear to be highly prevalent in the bus lane, and there is no correlation between the presence of the lane and greater incidence levels.

<sup>61</sup> Based on reporting from two bus lines that operate on the lane. There is additional LA Metro and municipal bus service on this bus lane that could have reported additional bike/bus collisions.



## On-Time Performance

Finding 8. There are mixed effects of both bus lanes on on-time performance.

Both bus lanes, on Wilshire Boulevard and Flower Street, have varied effects on on-time performance (OTP). As seen in **Table 3**, the presence of the bus lane correlates with greater on-time performance on eastbound service. However, westbound service on-time performance has declined considerably.

**Table 3:** Percent Change in On-time Performance on Wilshire Bus Lane

LINE	TIMEPOINTS ON CASE STUDY BUS LANE?	DIRECTION	PRE – IMPLEMENTATION (2011-2014)	POST – IMPLEMENTATION (2015-2019)	PERCENT CHANGE
<b>720</b>	<b>Yes</b>	<b>Eastbound</b>	<b>66.6%</b>	<b>68.6%</b>	<b>3%</b>
720	No	Eastbound	51.9%	52.0%	0%
<b>720</b>	<b>Yes</b>	<b>Westbound</b>	<b>74.1%</b>	<b>71.0%</b>	<b>-4%</b>
720	No	Westbound	84.5%	79.1%	-6%
<b>20</b>	<b>Yes</b>	<b>Eastbound</b>	<b>74.7%</b>	<b>79.2%</b>	<b>6%</b>
20	No	Eastbound	78.7%	73.1%	-7%
<b>20</b>	<b>Yes</b>	<b>Westbound</b>	<b>72.4%</b>	<b>62.6%</b>	<b>-14%</b>
20	No	Westbound	67.2%	64.5%	-4%
<b>Average percent change across segments of bus line with the bus lane</b>					<b>-2%</b>
Average percent change across segments of bus line without the bus lane					-4%

Author-made table based on In Service On Time Performance Reports accessed in LA Metro's Service Performance Analysis (SPA) portal. See Appendix F: On-Time Performance Analysis for more detailed breakdown of data.

- On Wilshire Line 720, the bus lane improved eastbound on-time performance by 3 percent, however, westbound service reliability declined by 4 percent.
- On Wilshire Line 20, the bus lane increased on-time performance on the eastbound direction by 6 percent, and westbound on-time performance fell by 14 percent.

When comparing across segments with and without a bus lane, there are mixed results. Westbound service of Line 720 declined less in segments with bus lanes. For Line 20, there is significantly worse on-time performance in segments with the bus lane. Comparing sections of the bus line with and without the bus lane, both the Metro 720 and 20 performed slightly more on-time on segments of line with the bus lane, but this was a decline from before the bus lane was implemented. This may be due to worsening congestion on Wilshire Boulevard, that has reduced service performance. Using OTP as a measure, this is only slightly mitigated by the presence of the bus lane.

Although I used a different methodology, these results are largely in line with findings from the Wilshire BRT: Before and After Study (2017). The 2017 study found that the bus lane improved eastbound on-time performance whereas Westbound on-time performance degraded, in large part due to the Purple Line Extension Project construction on Wilshire Boulevard, as well as existing traffic conditions (Phase I started in 2015).<sup>62</sup>

On the Flower Street bus lane, on-time performance results are also mixed (see **Table 4**). Since Flower Street runs one-way, I only look at the Metro J Line when traveling southbound, and Metro Line 460 when traveling south on the Flower Street bus lane and eastbound towards Anaheim.

- On the J Line, on-time performance declined by two percent on segments with the bus lane, and on segments without the bus lane, on-time performance increased by one percent.
- On Line 460, on-time performance improved by four percent on segments with the bus lane. However, on-time performance on segments without the bus lane increased by nine percent.

**Table 4: Percent Change in On-Time Performance on Flower Street Bus Lane**

LINE	TIMEPOINTS ON CASE STUDY BUS LANE?	DIRECTION	PRE-IMPLEMENTATION	POST-IMPLEMENTATION	PERCENT CHANGE
J Line	Yes	Southbound	77%	76%	-2%
J Line	No	Southbound	70%	71%	1%
460	Yes	Eastbound	78%	82%	4%
460	No	Eastbound	70%	77%	9%
<b>Average percent change across segments of bus line with the bus lane</b>					1%
<i>Average percent change across segments of bus line without the bus lane</i>					5%

*Author-made table based on In Service On Time Performance Reports accessed in LA Metro's Service Performance Analysis (SPA) portal. See Appendix F: On-Time Performance Analysis for more detailed breakdown of data.*

There are many factors that affect on-time performance. Although the reliability of the bus is an important measure for an agency such as Metro adhere to, it is an imprecise tool.<sup>63</sup> Although OTP is frequently used by US transit agencies, many are switching to more responsive and accurate means of measuring reliability, such as headway adherence. This report demonstrates

<sup>62</sup> Now called the D Line, the Purple Line Phase I project is extending the heavy rail system to Wilshire/La Cienega from Wilshire/Western, an additional 3.92 miles or 3 stations. For more information, go to <https://www.metro.net/projects/westside/>

<sup>63</sup> In an evaluation report of the Flower Street bus lane to the Board of Directors, LA Metro staff did not measure OTP, rather, they relied on changes in travel times using real-time location data from buses. Although this was an effective way to measure bus lane performance, it required considerable computational effort as it is not streamlined in service performance reports like OTP. For more information, see "Metro File # 2019-0663" (2019).

the limitations of using OTP to measure the performance of bus lanes. Current OTP measures are determined by many factors beyond vehicle running speed, and these would need to be controlled for to draw more definitive conclusions to the efficacy of bus lanes.

# Conclusion

This report uses two case studies, the Flower Street and Wilshire Boulevard bus lanes to measure the effect of enforcement on various outcomes, including operator experience, safety and on-time performance. The bus operator perspective has not been the primary focus of existing research on mixed-use bus lanes (Agrawal et al., 2013; Kiesling & Ridgway, 2006; Beaton et al., 2014). My findings show that bus lanes improve bus safety and performance, and even more so when there are robust management practices in place. This report fills a critical gap, and results of on-time performance and collision incidence align with findings from existing literature (Hendricks & Koos, 2012; Hillsman et al., 2012; Keeling et al., 2019; Kosinski et al., 2019).

Future studies should explore this research question with more data from enforced bus lanes. The Flower Street bus lane had been operational for less than a year, limiting my analysis. A larger sample of bus lanes would allow for future studies to control for more confounding factors, such as localized traffic conditions (following a methodology similar to Safran et al. 2014).

## Policy and Practice Implications

### ***Recommendations***

LA Metro should develop a comprehensive bus lane management strategy that includes a suite of solutions that can be deployed either system-wide or in specific violation hotspots. This report identifies five key recommendations for LA Metro to take into consideration for its existing and future bus lane network. These recommendations are broken down by short- and longer-term strategies, and include the following:

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Short-term strategies:

- **Recommendation 1.** LA Metro should explore different design configurations for current and future mixed-use bus lanes, as well as additional passive enforcement techniques. This could reduce the violation rates of bus lanes, but should be seen as a part of a comprehensive strategy with active enforcement.
- **Recommendation 2.** Metro could partner with the LA Department of Transportation to deploy Tiger Teams in congested, sections of existing bus lanes that are violation hotspots.

Longer-term strategies:

- **Recommendation 3.** LA Metro should pursue enabling legislation to allow for automated enforcement, and build a bus lane management system around this strategy.
- **Recommendation 4.** LA Metro should consider adopting new metrics to evaluate bus lane performance, such as headway adherence.
- **Recommendation 5.** Future bus lane planning should budget for management techniques as a part of the lifecycle cost of the lane. This will require strong inter-jurisdictional coordination and alignment around shared goals.

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Short-term recommendations

**Recommendation 1. LA Metro should explore different design configurations for current and future mixed-use bus lanes, as well as additional passive enforcement techniques. This could reduce the violation rates of bus lanes, but should be seen as a part of a comprehensive strategy with active enforcement.**

By deploying additional passive enforcement techniques, such as red-painted lanes, LA Metro could potentially reduce violation rates on bus lanes. LA Metro could also improve the efficacy of its existing passive enforcement, such as bus lane signs, by making them more visible, such as on overhead gantries. LA Metro should also explore different design solutions, such as offset bus lanes, in areas that are violation and congestion hotspots. Offset bus lanes can reduce parking and idling conflicts by reconfiguring the bus lane to be off the curb. Although curbside bus lanes are used for all of mixed-use lanes in LA County, this lane design is not recommended for streets with high congestion and large volumes of turning vehicles and pedestrian traffic, due to the high potential for delay. However, other design solutions, such as offset lanes, require more aggressive reconfiguring of street space, which must be balanced with physical and political constraints.

All of these techniques contribute to greater “self-enforcement” of the bus lane (Agrawal et al., 2013). Although all these passive techniques and design solutions require substantial upfront costs, they reduce the cost of enforcing the lane. However, relying on passive enforcement and design solutions cannot be a stand-alone strategy. These solutions must

be implemented with active enforcement techniques in order to be most effective. However, active enforcement can be used more strategically and in high-violation areas. This reduces the needs for a large enforcement budget, such as seen on Flower Street.

**Recommendation 2: Metro could partner with the LA Department of Transportation to deploy Tiger Teams in congested, sections of existing bus lanes that are violation hotspots.**

LA Metro's current bus lane management practices are not allowing for optimum bus operator safety, security, and on-time performance. Additionally, newer strategies, such as the deployment of a dedicated police unit on the Flower Street bus lane, are probably too costly and labor-intensive to be a sole strategy deployed system-wide. LA Metro could use its existing resources more strategically to produce better outcomes on all its mixed-use bus lanes. This could occur through the deployment of Tiger Teams, or highly visible intermittent parking enforcement, such as at the start of peak hours (or during rush hour on lanes that are 24/7). Having parking officials clear the lane, versus LAPD officers also decriminalizes bus lane enforcement. Tickets issued by LADOT parking officers are administrative fines, and routed through Metro's transit court rather than the courts. This report also finds that parked vehicles are the most common violation type, and cause the most delay, which could be targeted through such an approach.

Longer-term recommendations

**Recommendation 3. LA Metro should pursue enabling legislation to allow for automated enforcement, and build a bus lane management system around this strategy.**

While writing this report, LA Metro began seeking a local exemption, similar to San Francisco's, to allow for automated bus lane enforcement. Although this has been delayed until a later legislative session in 2020 (N. Borgman, personal communication, May 4, 2020), there is ample evidence for why LA Metro should consider to seek this legislative authority. Other applications of automated enforcement technology in Los Angeles County, such as red-light cameras, have proven to be effective at reducing incident and enforcement costs along Metro's busways and light rail guideways ("Metro Orange Line Speed Evaluation Study," 2015). Automated enforcement can also reduce opportunities for bias and decriminalize bus lane enforcement. Automated enforcement systems can largely replace boots-on-the-ground enforcement, and these systems can only issue administrative fines (Council et al., 2015; "Speed Enforcement Camera Systems Operational Guidelines," 2008). LA Metro's automated enforcement program should be administered through the agency's transit court, reducing the case load for the court system.

Early findings from other US cities with automated enforcement suggest that this approach would be lower cost than existing strategies deployed by LA Metro, and have a greater influence on changing the behavior of motorists. Both San Francisco and New York City cite

their automated bus lane enforcement systems as a key factor in increasing bus travel speeds, improving headway adherence, and changing motorist behavior (“Transit-Only Lane Enforcement,” n.d.; “MTA bus-mounted camera program begins issuing bus lane violations on B44 SBS route,” 2020).<sup>64</sup>

However, even if automated enforcement is legally approved, LA Metro should use it in tandem with other solutions, including boots-on-the-ground, design solutions, and passive enforcement techniques. LA Metro should develop a formalized bus lane management program, with a dedicated carve out of its existing enforcement budgets, and its capital program. This will require strong alignment of interjurisdictional partners.

**Recommendation 4: LA Metro should consider adopting new metrics to evaluate bus lane performance, such as headway adherence.**

LA Metro should develop new metrics such as headway adherence for measuring the performance of the bus lane network, and evaluating the effectiveness of different management techniques. Existing measurements used by the agency, including travel times and on-time performance, are not adequate metrics for directly measuring the effects of different management practices. Additionally, on-time performance creates operational practices that can actually slow down service for customers (“Elevated Standards for Bus Operations –Scheduling and Dispatching,” 2019; “Transit Capacity and Quality of Service Manual,” 2013). Other cities that have adopted headway adherence as a metric have seen considerable improvements in service reliability, ridership, and customer satisfaction (“Elevated Standards,” 2019).

**Recommendation 5: Future bus lane planning should budget for management techniques as a part of the lifecycle cost of the lane. This will require strong inter-jurisdictional coordination and alignment around shared goals.**

The Flower Street and Wilshire Boulevard bus lanes demonstrate two distinct approaches to bus priority infrastructure. The Wilshire Boulevard bus lane relied on high capital costs, and was folded into a \$31.5 million BRT project. The Flower Street bus lane represents a newer, lower-cost and more immediate approach to bus lane implementation. The Flower Street project relies on a tactical approach, with quick-build temporary roadway modifications that are low-cost (\$75,000 for installation).

Ultimately, despite these differences in cost, they both resulted in bus lanes with minimal design treatments (both are curbside bus lanes, limited to peak hour operating hours). Based on this report and other researchers’ findings, these types of lanes are associated

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<sup>64</sup> New York City MTA cited bus speed increases of 17 percent on segments of a route using automated cameras. An additional measure called the “wait assessment” which measures bus reliability was at 78.1 percent, more than 3 percent higher than the previous year. SFMTA reports reductions in delay as a result of the bus lane enforcement program, from 3 to 20 percent. Over a two-year timespan, the number of violations issued was cut in half, and repeat offenders only made up 1% of the total citations.

with high violation rates (Agrawal et al., 2013; Kiesling & Ridgway, 2006). The main difference between the Flower and Wilshire bus lane is that the Flower Street bus lane uses active enforcement to make up for limited passive enforcement and design treatment.

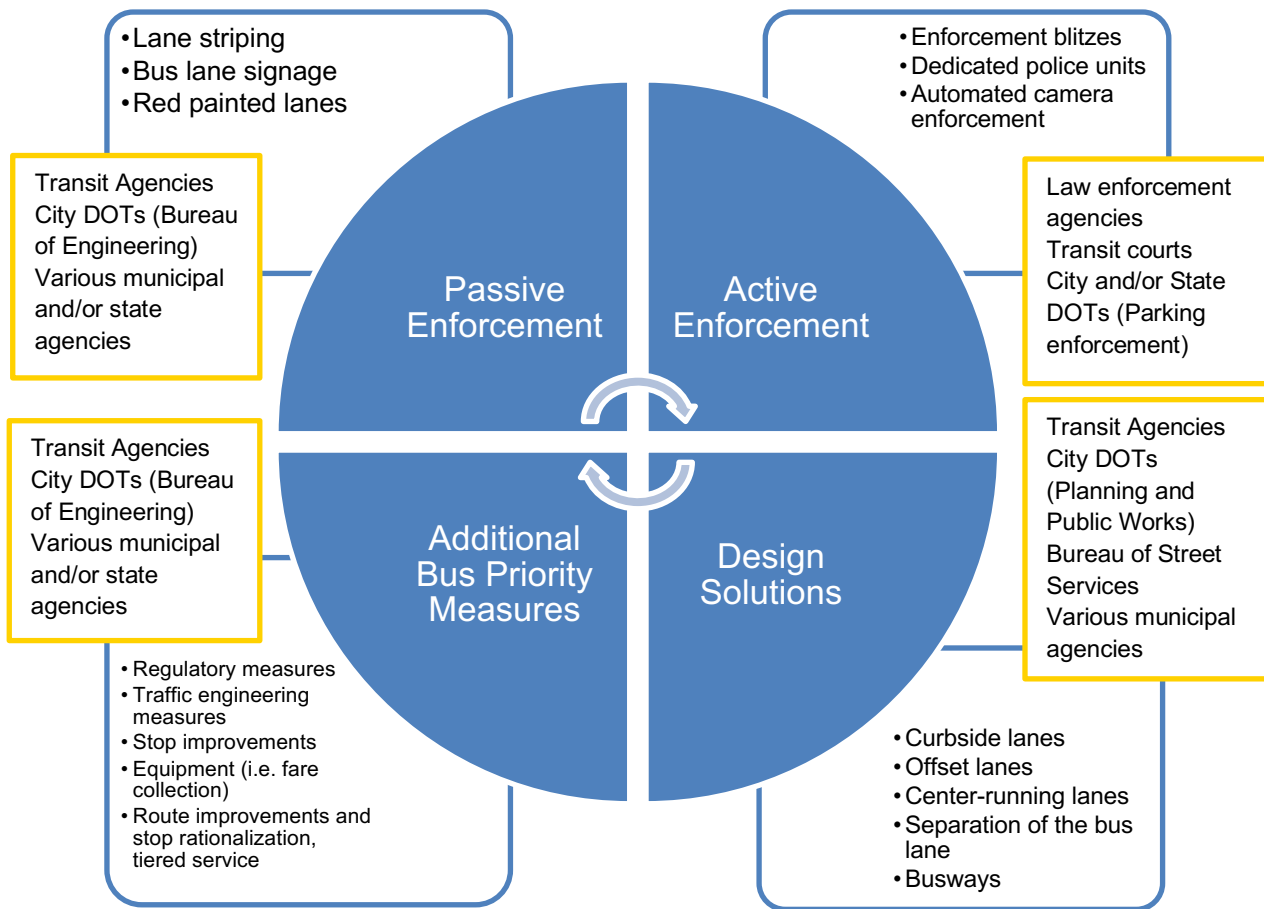
Regardless of a planner's chosen strategy when designing and installing a bus lane, they are essentially part of a balancing act. Costs not spent on design treatments and passive enforcement techniques that increase "self-enforcement" of the bus lane will be paid for through indirect ways, such as bus performance under targeted goals and minimal improvements in operational efficiency (Agrawal et al., 2013). If enforcement is implemented, enforcement costs will be higher to keep the lane clear.

Planners and policymakers should push for a bus lane design and implementation that affords the highest "scope of priority" that is physically and politically possible (Agrawal et al., 2013). Planners should be considering lifecycle costs when scoping out, and budgeting for, a bus lane project. Physical infrastructure needs to be matched with strong institutional arrangements. LA Metro could continue to deploy temporary bus lanes as a traffic mitigation strategy for major capital projects. This would allow bus lane installation and management costs to be folded into Metro's capital infrastructure budgets, such as the Purple Line Extension, and other future rail projects.

Although this report does not focus on bus priority measures beyond bus lanes, there are many measures that should be implemented in tandem with this infrastructure. Bus priority treatments, such as traffic engineering and regulatory measures, should be a part of an agency's decision-making when developing a comprehensive bus lane management program (visualized in **Figure 24**).



**Figure 24:** Proposed model for bus lane management system and institutional arrangements



*Author-made figure based on research.*

Excellent standards and guidance exist through such as groups as the National Association of City Transportation Officials (NACTO). However, decisions on bus lane deployment and management are often customized to the unique context of individual cities. Planners and policymakers have to determine the right combination of passive management techniques that are both achievable and provide the greatest performance outcomes. Agencies will have to formalize institutional partnerships between law enforcement, city governments, municipal agencies, and other key decision-makers. These partnerships are often challenging. Transit agencies, departments of transportation, and law enforcement agencies might have different, or even contrasting, operating practices and objectives. This report produces empirical data that can hopefully help create shared language and goals around bus lane management practices that can bridge this gap.

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# Appendices

## Appendix A: Information on Los Angeles Metro

Los Angeles County Metropolitan Transportation Authority (LA Metro) serves as the transportation planner and coordinator, designer, builder, and operator for the county. LA Metro's 1,433 square-mile service area encompasses 88 cities and 9.6 million inhabitants ("About Metro," metro.net). LA Metro is the third largest transit agency in the country by transit ridership, and the second largest by bus ridership (APTA Factbook 2018).<sup>65</sup> Across bus and rail services, Metro had roughly 370 million unlinked passenger trips in 2019 ("Interactive Estimated Ridership Stats," metro.net).

**Figure 25:** Key stats on LA Metro's bus system

<b>Bus Stops</b>	13,978
<b>Square Miles in Service Area</b>	1,479
<b>2019 Estimated Ridership - bus only</b>	277,308,845
<b>2019 Estimated Total Passenger Miles</b>	1,179,859,850
<b>Number of Bus Routes (Directly Operated and Contracted)</b>	165
<b>Total Metro Bus Fleet</b>	2,308
<b>Buses leased to contractors to provide service on Metro routes (Included in total)</b>	175
<b>Annual Revenue Service Hours (Directly Operated)</b>	6,400,781
<b>Annual Revenue Service Miles (Directly Operated)</b>	67,247,900
<b>Annual Revenue Service Hours (Contracted)</b>	483,124
<b>Annual Revenue Service Miles (Contracted)</b>	5,725,132

Source: LA Metro

<sup>65</sup> Ridership is measured by unlinked passenger trips. Includes both Directly Operated and Contracted Service.

**Figure 26:** Key stats on Metro Bus Lines referenced in this report

LINE NUMBER	NAME	DESCRIPTION	WEEKDAY AVERAGE RIDERSHIP (2019)	TOTAL ESTIMATED RIDERSHIP (2019)	TOTAL PASSENGER MILES (2019)
<b>Metro Line 720</b>	Wilshire Rapid	Eastbound to Downtown LA/Commerce – Westbound to Downtown LA/Santa Monica via Wilshire Blvd/Whittier Blvd	28,371	9,073,568	52,557,082
<b>Metro Line 20</b>	Wilshire Local	Eastbound to Downtown Los Angeles Westbound to Santa Monica via Wilshire Blvd	12,808	3,940,670	13,705,817
<b>Metro Line 910 (Routes 910/950)</b>	J Line (Formerly Silver Line)	Metro Busway – 910 El Monte – Harbor Gateway, 950 El Monte – San Pedro	17,558	5,209,169	53,466,003
<b>Metro Line 460</b>	n/a	Metro Local and Express – Northbound to Downtown Los Angeles – Southbound to Disneyland via I-110 Fwy, I-105 Fwy	4,883	1,598,917	24,979,251

Source: LA Metro

**Figure 27:** Key facts on Metro rail and busways referenced in this report

CURRENT NAME	FORMER NAME	YEAR BUILT	MILES	TYPE	STATIONS	CAPITAL COST
<b>Metro A Line</b>	Metro Blue Line	1990	21.3	Light Rail	22 (inc. 3 shared)	\$877 million
<b>Metro E Line</b>	Metro Expo Line	2012 Extension to Santa Monica, 2016	13.1	Light Rail	19 (inc. 2 shared)	\$2.4 billion
<b>Metro G Line</b>	Metro Orange Line	2005 Extension from Canoga Park to Chatsworth, 2012	18	Busway	18 n/a	\$484 million
<b>Metro J Line</b>	Metro Silver Line	2009 South Bay and El Monte via Downtown Los Angeles	n/a	Busway	11 n/a	\$587 million

Source: LA Metro



## Appendix B: Existing and Planned Bus Lanes in Los Angeles County

**Table 5:** Existing bus-only lanes and busways in Los Angeles County

Name	Year Built	Municipality	Infrastructure	Hours	Total Lane Miles	Enforcement
<b>Spring Street</b>	1974	City of Los Angeles	Shared lane, one-way	24-hr	0.5 miles	No dedicated unit / light enforcement
<b>Harbor Transitway</b>	1980's	City of Los Angeles, Carson	Exclusive guideway, bi-directional	24-hr	22 miles	Red light cameras
<b>Figueroa Street</b>	1990's	City of Los Angeles	Shared lane, one-way	24-hr	4.6 miles	Dedicated enforcement
<b>Broadway Boulevard</b>	2002	Santa Monica	Shared lane, one-way	24-hr	0.3 miles	No dedicated unit/ light enforcement
<b>Santa Monica Boulevard</b>	2002	Santa Monica	Shared lane, one-way	24-hr	0.3 miles	No dedicated unit/ light enforcement
<b>Orange Line Busway</b>	2005	City of Los Angeles	Exclusive guideway, bi-directional	24-hr	36 miles	Red light cameras
<b>Wilshire Boulevard</b>	2008	City of Los Angeles, Beverly Hills	Shared lane, bi-directional	Peak-only (6-9 am, 4-6 pm)	15.4 miles	No dedicated unit / light enforcement
<b>El Monte Busway</b>	2009	City of Los Angeles, Monterey Park, Rosemead, El Monte	Exclusive guideway, bi-directional	24-hr	22 miles	Red light cameras
<b>Cesar Chavez/Sunset Boulevard</b>	N/A	City of Los Angeles	Shared lane, bi-directional	Peak only, unidirectional (East bound 7-9 am, West bound 4-7pm), with enforcement during Dodgers games	2.4 miles	Dedicated unit only on Dodgers game days
<b>Lincoln Boulevard</b>	2017	Santa Monica	Shared lane, bi-directional	Peak only (7-9am, 4-7pm)	2.4 miles	No dedicated unit/ light enforcement
<b>Flower Street</b>	2019	City of Los Angeles	Shared lane, one-way	Evening peak-only (3-7pm)	1.8 miles	Dedicated enforcement

Source: Author-made table based on own research and Agrawal et al. 2013

**Table 6:** Planned Mixed-Use Bus-Only Lanes in Los Angeles County

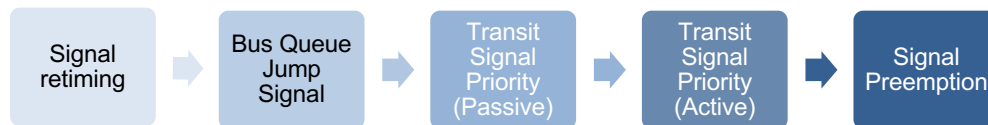
<b>CORRIDOR</b>	<b>PROJECTED OPENING YEAR</b>
<b>North San Fernando Valley</b>	2023-2025
<b>Vermont Blvd.</b>	2028-2030
<b>North Hollywood to Pasadena</b>	2022-2024

*Source: LA Metro*

## Appendix C: Traffic Engineering Measures

Traffic engineering measures allow for reduced wait times for buses at traffic signals. **Figure 28** shows different traffic engineering techniques that allow for greater bus priority, from minimal to maximum “scope of priority” or intensity of the bus priority measure. Retiming signal phases along a bus route entails extending the green phase time allocated to buses. This is a lighter touch than other signal treatments discussed below, but if implemented along the whole route, can allow for significant time savings (“Bus Priority Treatment Guidelines,” 2011).

**Figure 28:** Bus Priority Engineering Measures, by scope of Priority



*Author-made figure based on research*

A signal queue jumper gives buses a special signal to move through the intersection before other lanes are given a green light. This gives the bus a head start, which allows it to move in front of traffic and reduce the need for weaving. Although this measure requires special infrastructure at the intersection, it is less intensive than Transit Signal Priority because it does not require major reconfiguring of signal phases, which can increase overall traffic delay. Transit Signal Priority (TSP) is the designation of a special traffic signal phase for the part of the intersection serving the bus route. TSP creates either a longer green light or shorter red light, allowing them to move through the intersection faster. TSP can be either active or passive: active TSP always grants an extended green/truncated red regardless of whether the bus is on schedule or not, and passive TSP only grants priority when the bus is running late. Active TSP has a higher scope of priority as it grants buses priority more frequently than passive TSP. The highest scope of priority is given by signal preemption, which is largely not given to buses, unless under certain circumstances (such as in busway). Signal preemption is an automatic green light given to a transit vehicle at the intersection, and is primarily used for at-grade light rail transit, due to the substantial infrastructure requirements and the amount of delay caused for cross traffic. These priority measures have all been proven to be effective strategies to speed up the bus and improve headway adherence, or the reliability of service based on consistent wait times of passengers (“Bus Priority Treatment Guidelines,” 2011).

## Appendix D: Survey Responses to Vehicle Intrusions Hotspots

The following tables document open-ended responses from bus operators for the following survey question: “Are there certain cross streets, blocks, or sections of the Wilshire Boulevard [Flower Street] bus lane where these violations occur the most and/or cause the most delay? If so, please list those areas below.”

**Table 7:** Flower Street Bus Lane Intersections Mentioned

<b>INTERSECTION</b>	<b>NUMBER OF MENTIONS</b>	<b>PROPORTION OF ALL RESPONSES</b>
Pico	9	29%
Olympic	7	23%
7th	5	16%
Adams	4	13%
8th	3	10%
Washington	3	10%
9th	2	6%
Venice	2	6%
18th	2	6%
23rd	1	3%
28th	1	3%
<i>Total Respondents</i>		31

*Author-made table based on operator survey results*

**Table 8: Wilshire Boulevard Bus Lane Intersections Mentioned**

<b>INTERSECTION</b>	<b>NUMBER OF MENTIONS</b>	<b>PROPORTION OF ALL RESPONSES</b>
Vermont	9	20%
Western	9	20%
Normandie	5	11%
S La Brea	3	7%
Rampart	2	4%
Kingsley	2	4%
Westwood	2	4%
Cloverdale	1	2%
S Curson	1	2%
Fairfax	1	2%
San Vicente	1	2%
Comstock	1	2%
405	1	2%
Federal	1	2%
Barrington	1	2%
Bundy	1	2%
<i>Total Respondents</i>		46

*Author-made table based on operator survey results*

## Appendix E: Bus Lane Collision Incidence

**Table 9:** Wilshire Boulevard Bus Lane Collision Incidence Analysis

SELECTION OF TOP 10 COLLISION TYPES	INTERSECTIONS OUTSIDE WILSHIRE BUS LANE			INTERSECTIONS IN WILSHIRE BUS LANE			SIGNIFICANCE
	Pre-Install	Post-Install	Percent Change	Pre-Install	Post-Install	Percent Change	
Vehicle turns right in front of bus	48	16	-67%	20	6	-70%	<b>0.002</b>
Straight ahead - other vehicle from right	49	35	-29%	20	6	-70%	<b>0.002</b>
Bus hits vehicle (includes drifting back)	29	18	-38%	9	4	-56%	0.511
Other vehicle hits bus (includes drifting back)	37	26	-30%	8	9	13%	0.252
Collision from vehicles parked at curb	21	15	-29%	6	5	-17%	0.824
Other vehicle involved with bus standing in zone - sideswipe	28	21	-25%	3	3	0%	0.739
Straight ahead - other vehicle from left	88	74	-16%	34	25	-26%	0.522
Collision with fixed stationary object	85	80	-6%	27	16	-41%	0.085
Sideswipe (other vehicle passing our vehicle)	124	120	-3%	39	42	8%	0.556
Sideswipe (while passing other vehicle)	40	41	3%	9	8	-11%	0.741

**Table 10: Wilshire Boulevard Bus Lane Collision Incidence Analysis (cont'd)**

SELECTION OF TOP 10 COLLISION TYPES	INTERSECTIONS IN WILSHIRE BUS LANE			INTERSECTIONS OUTSIDE OF WILSHIRE BUS LANE			SIGNIFICANCE
Total Collisions (all 27 incident types)	223	153	-31%	462	439	-5%	0.009

*Author-made table based on research (data provided by LA Metro)*

**Table 11: Flower Street Bus Lane Collision Incidence Analysis**

TOTAL COLLISIONS	INTERSECTIONS OUTSIDE THE FLOWER STREET BUS LANE			INTERSECTIONS IN THE FLOWER STREET BUS LANE			SIGNIFICANCE
	Pre-Install	Post-Install	Percent Change	Pre-Install	Post-Install	Percent Change	P-value (.05)
	8	16	100%	29	34	17%	0.28

*Author-made table based on research (data provided by LA Metro)*

## Appendix F: On-Time Performance Analysis

### Wilshire Bus Lane: Line 20 (Local)

**Table 12:** Percentage On-Time at Timepoints, Line 20 – Eastbound, Weekday Service

TIMEPOINT	ON BUS LANE?	PRE-IMPLEMENTATION				POST-IMPLEMENTATION			
		2011	2012	2013	2014	2016	2017	2018	2019
Wilshire/ Santa Monica	No	76.3%	80.4%	77.0%	77.3%	N/A	N/A	N/A	N/A
Wilshire/ 14th	No	71.7%	80.5%	82.4%	84.3%	68.3%	82.4%	82.1%	84.0%
Wilshire/ Fairfax	Yes	74.1%	76.1%	73.8%	74.5%	71.4%	68.9%	N/A	N/A
Wilshire/ La Brea	Yes	73.7%	75.3%	74.1%	74.2%	N/A	N/A	N/A	N/A
Wilshire/ Vermont	Yes	69.9%	70.2%	68.4%	69.3%	66.0%	67.0%	69.1%	70.1%
Wilshire/ Western	Yes	72.9%	73.5%	72.3%	71.7%	69.7%	67.7%	N/A	N/A
Wilshire/ Westwood	Yes	79.4%	84.1%	82.6%	83.0%	80.9%	82.2%	81.9%	81.7%

**Table 13:** Percentage On-Time at Timepoints, Line 20 – Westbound, Weekday Service

TIMEPOINT	ON BUS LANE?	PRE-IMPLEMENTATION				POST-IMPLEMENTATION			
		2011	2012	2013	2014	2016	2017	2018	2019
Wilshire/ Santa Monica	No	62.6%	64.1%	59.4%	58.6%	N/A	62.0%	54.3%	N/A
Wilshire/ 14th	No	59.2%	60.7%	62.6%	67.1%	59.1%	66.1%	68.6%	72.1%
Wilshire/ Alvarado	No	78.1%	79.0%	76.0%	78.4%	67.8%	65.6%	67.9%	61.6%
Wilshire/ Fairfax	Yes	69.7%	70.2%	68.1%	65.3%	59.1%	58.3%	62.0%	47.9%
Wilshire/ La Brea	Yes	71.4%	72.7%	70.8%	69.1%	N/A	N/A	N/A	N/A
Wilshire/ Vermont	Yes	76.3%	77.9%	75.1%	78.2%	68.6%	66.5%	68.7%	59.4%
Wilshire/ Western	Yes	73.6%	75.1%	71.5%	74.0%	66.8%	65.0%	66.6%	N/A

*N/As are due to moved or unreported timepoints. Data reflect only ISOTP timepoints. Author-made tables from Metro's In Service On-Time Performance Reports, through the Service Performance Analysis portal.*



### Wilshire Bus Lane: Line 720 (Rapid)

**Table 14:** Percentage On-Time at Timepoints, Line 720 – Westbound, Weekday Service

TIMEPOINT	ON WILSHIRE BUS LANE?	PRE-IMPLEMENTATION				POST-IMPLEMENTATION			
		2011	2012	2013	2014	2016	2017	2018	2019
6th/Main	No	57.2%	53.4%	54.2%	47.8%	49.6%	51.0%	53.4%	N/A
Whittier/Soto	No	52.3%	50.3%	52.2%	47.4%	54.6%	50.6%	52.6%	51.9%
Wilshire/Barrington	Yes	88.9%	75.0%	64.7%	N/A	N/A	N/A	N/A	N/A
Wilshire/La Brea	Yes	59.2%	62.1%	63.8%	62.4%	N/A	N/A	N/A	N/A
Wilshire/Vermont	Yes	57.4%	58.7%	59.1%	55.8%	58.4%	58.9%	64.4%	67.4%
Wilshire/Westwood	Yes	66.0%	74.9%	75.3%	75.3%	73.5%	78.6%	74.1%	73.8%

**Table 15:** Percentage On-time at Timepoints, Line 720 – Eastbound, Weekday Service

TIMEPOINT	ON WILSHIRE BUS LANE?	PRE-IMPLEMENTATION				POST-IMPLEMENTATION			
		2011	2012	2013	2014	2016	2017	2018	2019
5th/Main	No	82.4%	84.2%	81.4%	81.8%	72.5%	79.4%	77.0%	74.7%
Whittier/Soto	No	85.1%	87.6%	86.7%	87.0%	79.9%	84.9%	83.6%	81.1%
Wilshire/La Brea	Yes	69.8%	70.5%	72.5%	67.0%	N/A	N/A	N/A	N/A
Wilshire/Vermont	Yes	77.3%	80.3%	77.3%	77.7%	67.9%	74.7%	70.3%	71.2%

*N/As are due to moved or unreported timepoints. Data reflect only ISOTP timepoints. Author-made tables from Metro's In Service On-Time Performance Reports, through the Service Performance Analysis portal.*

### Flower Street Bus Lane: J Line

**Table 16:** Percentage On-time at Timepoints, J Line – Southbound, Weekday Service

TIMEPOINT	ON FLOWER ST BUS LANE?	JUNE 1 <sup>ST</sup> , 2018 – JANUARY 31 <sup>ST</sup> , 2019 (PRE-IMPLEMENTATION)	JUNE 1 <sup>ST</sup> , 2019 – JANUARY 31 <sup>ST</sup> , 2020 (POST-IMPLEMENTATION)
Harbor Gateway Transit Center	No	70.2%	70.8%
Flower / 7th	Yes	77.1%	75.8%

*Data reflect only ISOTP timepoints. Author-made tables from Metro's In Service On-Time Performance Reports, through the Service Performance Analysis portal.*

**Flower Street Bus Lane: Line 460**

**Table 17:** Percentage On-time at Timepoints, Line 460 – Eastbound, Weekday Service

<b>TIMEPOINT</b>	<b>ON FLOWER ST BUS LANE?</b>	<b>JUNE 1<sup>ST</sup>, 2018 – JANUARY 31<sup>ST</sup>, 2019 (PRE-IMPLEMENTATION)</b>	<b>JUNE 1<sup>ST</sup>, 2019 – JANUARY 31<sup>ST</sup>, 2020 (POST-IMPLEMENTATION)</b>
5th/Los Angeles	No	78.1%	81.5%
Flower/Olympic	Yes	70.4%	76.8%

*Data reflect only ISOTP timepoints. Author-made tables from Metro's In Service On-Time Performance Reports, through the Service Performance Analysis portal.*

## Appendix G: Survey Instrument

The survey below was distributed to bus operators of both the Wilshire and Flower Street bus-only lanes. Although the Wilshire and Flower Bus Lane Surveys were separately administered and had their own URL link, they are represented below as one survey, with the alternative name in brackets. The subject (Wilshire or Flower Street bus lanes) was the only difference in the surveys.

<b>Welcome to the Wilshire [Flower] Bus Lane Survey!</b>	
This short (5 minute) survey consists of a series of preset questions and a comment box at the end. It is designed to assess your experience of the Wilshire [Flower Street] Bus-Only Lane as a bus operator. Your input will help Metro determine what types of conflicts are occurring in the bus-only lanes, how frequently they are occurring, and how they affect your experience as an operator. Your participation is voluntary, and your answers will be kept confidential.	
<b>*1. Please enter your badge number below. This will not be linked to your survey responses, and used only to make sure you are compensated for your time. *</b>	
Badge #	
*badge numbers were required so that bus operators could receive 20 minutes “regular straight time” of compensation for completing the survey. Survey results were anonymized before I conducted data analysis.	
<b>*2. On which of the following routes have you operated a bus in the past three months? (select all that apply)</b>	
<b><i>Routes asked for Wilshire Bus Lane</i></b>	
	Metro 20
	Metro 720
	Big Blue Bus 2
	Big Blue Bus 7
	Big Blue Bus Rapid 7
	None of the above
<b><i>Routes asked for Flower Street Bus Lane</i></b>	
	Metro 910/950
	Metro 460
	Metro 456
	None of the above
	(if none of the above, survey ends)

(if anything but none of the above, the following question is asked for each selection)

<b>*3. About how often do you operate the _____? (asked for EACH selection of Question 1)</b>	
	Almost every work day
	At least once a week
	At least once a month

Less than once a month
------------------------

<b>*4. How frequently, if ever, do you use the Wilshire bus-only lane [Flower Street] when operating a bus on Wilshire [Flower Street]?</b>	
Very Frequently	
Frequently	
Infrequently	
Very Infrequently	
Never	

*(if answer never, the following skip logic applies AFTER question 5)*

<b>*5. Thinking about your experience using the Flower Street bus lane, how much do you agree or disagree with the following statements? **</b>				
The bus lane increases bus travel speed				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
The bus lane increases the reliability of bus on-time performance				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable

*\*\*this question was added after the first round of surveying on Wilshire Boulevard.*

<b>6. How much do the following issues affect your decision to not use the Wilshire Boulevard [Flower Street] bus lane?</b>		
Other buses traveling in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Other buses stopped in the bus lane, such as at a bus stop		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Personal cars driving in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Vehicles making legal right turns in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Uber and Lyft cars or taxis driving in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Bicyclists traveling in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
E-scooters traveling in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Pedestrians walking/standing in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Delivery or utility trucks traveling in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Police cars/Emergency vehicles driving in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable
Trash cans or other objects in the bus lane		
Does Not Affect My Decision	Affects My Decision	Not Applicable

<b>*7. Please select the three things that affect your decision to not use the Wilshire Boulevard [Flower Street] bus lane the most?</b>	
<input type="checkbox"/>	Other buses traveling in the bus lane
<input type="checkbox"/>	Other buses stopped in the bus lane, such as at a bus stop
<input type="checkbox"/>	Personal cars driving in the bus lane
<input type="checkbox"/>	Personal cars parked in the bus lane
<input type="checkbox"/>	Vehicles making legal right turns in the bus lane
<input type="checkbox"/>	Uber and Lyft cars or taxis driving in the bus lane
<input type="checkbox"/>	Uber and Lyft cars or taxis stopped in the bus lane
<input type="checkbox"/>	Bicyclists traveling in the bus lane
<input type="checkbox"/>	E-scooters traveling in the bus lane
<input type="checkbox"/>	Bicycles or E-Scooters parked in the bus lane
<input type="checkbox"/>	Pedestrians walking/standing in the bus lane
<input type="checkbox"/>	Delivery or utility trucks traveling in the bus lane
<input type="checkbox"/>	Delivery or utility trucks parked in the bus lane
<input type="checkbox"/>	Police cars/Emergency vehicles driving in the bus lane
<input type="checkbox"/>	Police cars/Emergency vehicles parked in the bus lane
<input type="checkbox"/>	Trash cans or other objects in the bus lane
<input type="checkbox"/>	None of the above

**8. Do you have any other comments regarding why you prefer not to use the Wilshire Boulevard [Flower Street] bus lane?**  
 (comment box)

<b>9. *Optional* If Metro conducted focus groups with bus operators to gain more insights on how we can improve the Wilshire [Flower Street] bus lane, would you be interested in attending? (you would be compensated for your time)</b>	
<input type="checkbox"/>	Definitely Would Attend
<input type="checkbox"/>	Probably Would Attend
<input type="checkbox"/>	Probably Would Not Attend
<input type="checkbox"/>	Definitely Would Not Attend

*(if anything but “definitely would not attend”, the following skip logic applies)*

**9.1. Please provide a work phone number, email address, or badge # so we can contact you if focus groups are conducted in the future. (this is needed only to contact those who are interested and is not linked to your survey responses)**  
 (short answer comment)

*(if answer anything but never in Q3, the following skip logic applies)*

<b>6. In your experience, how often do each of the items below cause delay in the Wilshire Boulevard [Flower Street] bus lane?</b>		
Other buses traveling in the bus lane		
Never	Sometimes	Always
Other buses stopped in the bus lane, such as at a bus stop		

Never	Sometimes	Always
Personal cars illegally driving in the bus lane		
Never	Sometimes	Always
Personal cars illegally parked in the bus lane		
Never	Sometimes	Always
Vehicles making legal right turns in the bus lane		
Never	Sometimes	Always
Uber and Lyft cars or taxis driving in the bus lane		
Never	Sometimes	Always
Uber and Lyft cars or taxis stopped in the bus lane		
Never	Sometimes	Always
E-scooters traveling in the bus lane		
Never	Sometimes	Always
Bicyclists traveling in the bus lane		
Never	Sometimes	Always
Bicycles or E-Scooters parked in the bus lane		
Never	Sometimes	Always
Pedestrians walking/standing in the bus lane		
Never	Sometimes	Always
Delivery or utility trucks traveling in the bus lane		
Never	Sometimes	Always
Delivery or utility trucks parked in the bus lane		
Never	Sometimes	Always
Police cars/Emergency vehicles driving in the bus lane		
Never	Sometimes	Always
Police cars/Emergency vehicles parked in the bus lane		
Never	Sometimes	Always
Trash cans or other objects in the bus lane		
Never	Sometimes	Always

<b>*7. Please select the three things that affect your ability to use the Wilshire Boulevard [Flower Street] bus lane the most.</b>	
<input type="checkbox"/>	Other buses traveling in the bus lane
<input type="checkbox"/>	Other buses stopped in the bus lane, such as at a bus stop
<input type="checkbox"/>	Personal cars driving in the bus lane
<input type="checkbox"/>	Personal cars parked in the bus lane
<input type="checkbox"/>	Vehicles making legal right turns in the bus lane
<input type="checkbox"/>	Uber and Lyft cars or taxis driving in the bus lane
<input type="checkbox"/>	Uber and Lyft cars or taxis stopped in the bus lane
<input type="checkbox"/>	Bicyclists traveling in the bus lane
<input type="checkbox"/>	E-scooters traveling in the bus lane
<input type="checkbox"/>	Bicycles or E-Scooters parked in the bus lane
<input type="checkbox"/>	Pedestrians walking/standing in the bus lane
<input type="checkbox"/>	Delivery or utility trucks traveling in the bus lane
<input type="checkbox"/>	Delivery or utility trucks parked in the bus lane
<input type="checkbox"/>	Police cars/Emergency vehicles driving in the bus lane
<input type="checkbox"/>	Police cars/Emergency vehicles parked in the bus lane
<input type="checkbox"/>	Trash cans or other objects in the bus lane
<input type="checkbox"/>	None of the above

(if anything but none of the above, the following skip logic applies)

<b>8. Thinking about those top three things that affect your experience operating a bus in Wilshire Boulevard [Flower Street] bus lanes, how much do you agree or disagree with the following statements?</b>				
Results in conditions where I have to weave in and out of the bus lane				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Puts me in a higher risk of collision with another vehicle				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Causes me to fall off schedule – either late or early to a timepoint				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Causes me to miss a scheduled break				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Results in infrequent service for riders				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Results in more frustrated customers				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Increases the likelihood of violence or aggression among customers				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable
Increases my stress in operating the bus				
Strongly Disagree	Disagree	Agree	Strongly Agree	Not Applicable

<b>9. Are there certain cross streets, blocks, or sections of the Wilshire Boulevard [Flower Street] bus lane where these violations occur the most and/or cause the most delay? If so, please list those areas below:</b>
(comment box)

<b>*10. Have you noticed any changes in the past month with regards to the number of illegally parked vehicles in the Wilshire [Flower Street] Bus Lane?</b>
Major decrease in parked vehicles
Minor decrease in parked vehicles
No change in number of parked vehicles
Minor increase in parked vehicles
Major increase in parked vehicles

<b>11. If there is anything we missed, please provide additional thoughts or comments below.</b>
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(comment box)

**12. \*Optional\* If Metro conducted focus groups with bus operators to gain more insights on how we can improve the Wilshire [Flower Street] bus lane, would you be interested in attending? (you would be compensated for your time)**

Definitely Would Attend

Probably Would Attend

Probably Would Not Attend

Definitely Would Not Attend

(if anything other than “definitely would not attend”, skip logic applies)

**12.1. Please provide a work phone number, email address, or badge # so we can contact you if focus groups are conducted in the future. (this is needed only to contact those who are interested and is not linked to your survey responses)**

(short answer comment)

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**Thank you for completing the survey! We value your unique insight as a bus operator and appreciate your time.**

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