Title

Saved by the... Bus? Analyzing Safety Outcomes on Streets with Bus Lanes

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Publication Date
2022-06-01

DOI
doi:10.17610/T6DK6X

STUDENT CAPSTONE REPORT

Saved by the... Bus?

Analyzing Safety Outcomes on Streets with Bus Lanes

A comprehensive project submitted in partial satisfaction of the requirements for the degree Master of Urban & Regional Planning

Erik Felix • June 2022
Client: Los Angeles Department of Transportation (LADOT)
Faculty Advisor: Dr. Anastasia Loukaitou-Sideris

UCLA Lewis Center for Regional Policy Studies

UCLA Institute of Transportation Studies

Technical Report Documentation Page

1. Report No.	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Saved by the… Bus? Analyzing Safety Outcomes on Streets with Bus Lanes		**5. Report Date** 2022-06-10 **6. Performing Organization Code** UCLA-ITS
7. Author(s) Erik Felix		**8. Performing Organization Report No.** LA2144
9. Performing Organization Name and Address Institute of Transportation Studies, UCLA 3320 Public Affairs Building Los Angeles, CA 90095-1656		**10. Work Unit No.** N/A **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address UCLA Institute of Transportation Studies www.its.ucla.edu		**13. Type of Report and Period Covered** Final **14. Sponsoring Agency Code** UC ITS

15. Supplementary Notes
doi:10.17610/T6DK6X

16. Abstract
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17. Key Words transit transportation planning safety Los Angeles		**18. Distribution Statement** No restrictions.	
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 131	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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Acknowledgements

Quiero darle gracias a mi madre, Rosa Alvarado Felix. Su cariño y ejemplo desde niñez hasta hoy en dia me a dado la capicidad para realizar mis metas. Esta oportunidad no pudiera ser posible sin sus sacrificios y su apoyo.

Special thanks to Matt Gertz at LADOT for their support and input through every step of this project's process. Special thanks to Dr. Anastasia Loukatiou-Sideris for her incisive insights and thoughtful edits. I appreciate both of you for your dedication to this project. Thank you to Audrey Toth for being an unconditionally supportive and caring partner during my time in the MURP program and while developing this project. Thank you to Evelyn Blumenberg and Madeline Wander for kindly dedicating their time to assisting me in research design and analysis. Lastly, thank you to my fellow UCLA MURP 2022 graduating cohort. You are a magnetically inspiring group of individuals. Your warmth and support were constant sources of motivation throughout the MURP program.

This report was made possible by generous financial support from the UCLA Lewis Center for Regional Policy Studies.

As a land grant institution, the Lewis Center for Regional Policy Studies at UCLA acknowledges the Gabrielino/Tongva peoples as the traditional land caretakers of Tovaangar (Los Angeles basin, So. Channel Islands).

Disclaimer

This report was prepared in partial fulfillment of the requirements for the Master in Urban and Regional Planning degree in the Department of Urban Planning at the University of California, Los Angeles. It was prepared at the direction of the Los Angeles Department of Transportation (LADOT) as a planning client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client.

Saved by the… Bus?

Analyzing Safety Outcomes on Streets with Bus Lanes

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UCLA Lewis Center for Regional and Policy Studies
June 2022

University of California, Los Angeles
Meyer and Renee Luskin School of Public Affairs
Department of Urban Planning

Client: Los Angeles Department of Transportation
Faculty Advisor: Dr. Anastasia Loukaitou-Sideris

A comprehensive project submitted in partial satisfaction of the requirements for the degree Master of Urban and Regional Planning

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Executive Summary

Over the past 10 years, mixed-use bus lanes in Los Angeles have expanded from four miles (Agrawal, 2012) to more than 27 miles of county streets (Halls, 2020). Mixed-use bus lanes, from here on referred to as bus lanes, are lanes designated exclusively for buses that operate on general traffic streets. Understanding if bus lanes make streets safer for all users is imperative, especially in a city where traffic fatalities are rampant. Los Angeles ranked second in the nation for pedestrians killed by motor vehicles in 2015 (Garcetti, 2015). While the mileage of planned and installed bus lanes increases, it is still unclear how they affect street safety. My research report attempts to provide clarity to this unknown by examining the impact that all-day bus lanes and peak-hour bus lanes have on street safety. I focus on four Los Angeles bus lanes – three are peak hour lanes and one is an all-day lane. I also look at two streets that currently have no bus lanes, but that the Los Angeles Department of Transportation (LADOT) and the Los Angeles County Metropolitan Transportation Authority (LA Metro) have identified as candidates for new installed bus lanes (Linton, 2021).

To understand how street safety may have shifted after bus lane installation, I run a descriptive statistical analysis of crash data. I found that collisions increased during bus lane hours on all but one of the studied corridors but became less severe, less fatal and involved a smaller proportion of pedestrians. The proportion of severe-injury and fatal collisions either stayed constant or decreased on all the studied bus lane corridor segments. The proportion of pedestrian-involved collisions either stayed constant or decreased on peak hour corridors, but increased on the one analyzed all-day corridor. The adverse outcomes for pedestrians on the all-day corridor may be due to its high concentration of pedestrian activity (LADOT, 2021a). The streets with no bus lanes saw mixed outcomes. These findings indicate that bus lanes may help reduce collision severity, fatalities, and pedestrian-involved collisions. However, the only segment that saw a decrease in collisions during bus lane hours was Wilshire Boulevard between Park View Street and Western Avenue. This is worth further analysis since this peak hour bus lane segment of Wilshire Boulevard is accommodated similarly compared to the other studied bus lane segments.

I follow with a qualitative analysis of one of the bus lane corridors with the highest increases in collisions, and another of the sole bus lane corridor with a decrease in collisions. By conducting a site visit to each corridor, I assessed the street design elements, and any tradeoffs made to accommodate the bus lanes that may have attributed to the corridor's enhanced or diminished safety. I found that the difference in collision frequency had to do with block length, vehicle speeds, and the presence of controlled crosswalks; and the similarities in increased bicyclist-involved collisions had to do with a lack of bicycle infrastructure.

The results of my research imply that the accommodations made for the bus lanes during the study period were not enough to enhance safety. Still, bus lanes can enhance street safety if installed in tandem with thoughtful, complementary design elements. I make the following policy and planning recommendations for future bus lanes in Los Angeles:

- **Paint bus lanes red**
- **Operate offset-running bus lanes**
- **Educate and encourage drivers not to illegally use the bus lane**
- **Provide space to temporarily park on parallel or collector streets during bus lane hours**
- **Limit the possibility for left turns**
- **Install center median strips or pedestrian islands on corridors**
- **Install controlled crosswalks at intersections and on extensive blocks**
- **Future study of new and forthcoming bus-only lanes and red painted lanes**

Bus lanes are an effective tool to increase bus efficiency but require more than just a dedicated curbside lane with little additional complementary design elements to help improve street safety. Providing efficient bus service is integral to local and regional mobility and sustainability goals. But incorporating bus lanes into streetscapes must be done thoughtfully and effectively, and in tandem with complementary designs and accommodations that promotes safe streets for all.

Introduction

Over the past 10 years, mixed-use bus lanes in Los Angeles have expanded from four miles (Agrawal, 2012) to 27 miles of county streets (Halls, 2020), with more slated as part of Metro's NextGen bus plan (Mass Transit Mag, 2021). Mixed-use bus lanes, from here on referred to as bus lanes, are lanes designated exclusively for buses that operate on general traffic streets. As the mileage of planned and installed bus lanes increases, it is still unclear how they affect street safety. My research report will examine if there are differences in severe and fatal traffic collisions among streets with all-day bus lanes, peak-hour bus lanes, and no bus lanes. Can these differences be explained by the trade-offs made to accommodate each bus lane type? My analysis begins with case studies on three U.S. bus lane programs: New York City, San Francisco, and Seattle. Next, I conduct a descriptive statistical analysis using collision data from bus lane corridors in Los Angeles. Based on my statistical findings, I complete two sites visits to gather qualitative data to inform my findings. I conclude with policy and planning recommendations.

Background

The Los Angeles Mobility Plan 2035 and Metro's Complete Streets Policy indicate a push to invest in more sustainable modes of transportation that are inclusive of and safer for all users (LACMTA, 2018b). At the same time, Los Angeles' wide thoroughfares offer the opportunity to accommodate multimodal, sustainable transportation uses like bus lanes (Huang and Vallianatos, 2021). Understanding if bus lanes make streets safer for all users is thus imperative, especially in a city where traffic fatalities are rampant. In 2015, pedestrians and bicyclists made up 56% of all severe and fatal traffic collisions in the City, and Los Angeles ranked second in the nation for pedestrians killed by motor vehicles (Garcetti, 2015). That same year Los Angeles Mayor Eric Garcetti launched Vision Zero with the goal of eliminating traffic deaths by 2025 (Kimbel-Sannit, et al, 2019). But since then, pedestrian deaths have increased by 36% (Schmitt and Davis-Overstreet, 2021). Pedestrian deaths in Los Angeles are concentrated in specific corridors – many of which are in Black and Latinx communities (Brozen and Ekman, 2020). Six percent of the city's streets account for 70% of all pedestrian fatalities and severe injuries (LADOT, 2021b). The Los Angeles Department of Transportation (LADOT) High Injury Network map shows Alvarado Street, Figueroa Street, 5th Street, 6th Street, and La Brea Avenue as part of this unsafe street network (LADOT, 2021b). Each of these streets has or will soon have a bus lane (Linton, 2021b). The most unsafe streets in the city are seeing long overdue modifications, but whether the proper modifications are being done to enhance street safety is unclear.

Literature Review

The existing literature on bus lanes in the U.S. has shown mixed results regarding their effect on traffic safety. In an analysis of the Wilshire Boulevard and Flower Street bus lanes in Los Angeles, traffic-related collisions declined on Wilshire Boulevard but did not change on Flower Street (Halls, 2020). However, the author noted that Flower Street bus lane was operational for less than a year, resulting in a limited amount of data (Halls, 2020). Reports of the Wilshire Boulevard bus lanes from 2004 and 2018 also found an increase in traffic safety due in part to buses no longer having to merge into traffic (LACMTA, 2004) (LACMTA, 2018a). My study builds upon these projects by analyzing a larger sample of bus lanes and including an analysis of differences between peak hour and all-day bus lanes. In San Francisco, an analysis of three installed bus lanes saw a 16% decrease in collisions and a 24% drop in injury collisions compared to the rest of the city (SFMTA, 2017). On the other hand, another San Francisco bus lane on Mission Street saw no change to pedestrian and auto collisions compared to before installation but did see bus collisions decrease by 85% (SFMTA, n.d.). The Mission Street bus lane was analyzed less than a year after installation and may also have had a limited sample of data. A 2013 study of dedicated bus lane configuration in the Bronx borough of New York City found that offset dedicated bus lanes best balanced transit and pedestrian needs more than center-running or curbside lanes (Beaton, et al, 2013). Offset bus lanes occupy the travel lane adjacent to the curb lane. Center-running lanes occupy the travel lane closest to the centerline of a two-way street. Offset bus lanes balance transit and pedestrian needs by offering the most pedestrian space, shortening walking distances to the bus, and deterring users from intermingling – all of which promotes increased safety (Beaton, et al, 2013). Similarly, another study of New York City bus lanes concluded that an offset configuration with red markings was best for bus lane usage and for reducing obstruction (blockage of the lane, typically from a private vehicle) (Safran, et al, 2014). Though this study did not consider safety, the reductions in obstructions reduced the likelihood of merging into traffic which has been found to increase traffic safety (LACMTA, 2004) (LACMTA, 2018a) (Goh, et al, 2013) (Goh, et al, 2014). An early study of bus lanes in Chicago in 1984 found an initial spike in bus-pedestrian crashes after their installation, but eventual long-term decreases in all pedestrian crashes and bus crashes (LaPlante and Harrington, 1984). Due to the relatively recent nature of most of America's bus lanes, and the limited number of studies that have analyzed them, further review is necessary.

There is a robust collection of literature from other countries that also shows mixed results of bus lane impacts on street safety, also emphasizing that outcomes depend on the way bus lanes are accommodated. Graham Currie and Kelvin Goh have done extensive research on Australian bus lanes and their safety benefits. Their 2014 study found a significant reduction in buses hitting stationary objects and vehicles due to less bus maneuvering (Goh, et al, 2014). Another study from 2013 found that streets with bus lanes experience a 14% reduction in crashes for multiple reasons including bus lanes:

1) serving as a roadside buffer between travelling cars and other users, 2) increasing sight distances at unsignalized intersections, 3), slowing traffic to safer speeds, and 4) minimizing bus maneuvering (Goh, et al, 2013). A study in Hong Kong of seven different sites found a statistically significant decrease in public bus crashes, both fatal and serious, at two sites (Tse, et al, 2012). But considering that its results from five other sites were not statistically significant, the study's results were not conclusive (Tse, et al, 2012). Research on Latin American and European corridors found that bus lanes reduced severe and fatal crashes by over 50%, though the increase in street safety resulted not from the bus lanes themselves but from the street modifications made to accommodate them (Duduta, et al, 2015). Street modifications included fewer traffic lanes, installed center medians, shorter crosswalks, and prohibited left turns at intersections, all of which made streets safer (Duduta, et al, 2015). A study in Israel found a similar relationship with center-running bus lanes being safer than curbside bus lanes – with the safest configuration being a center-running bus lane next to one mixed-traffic lane (Gitelman, et al, 2020).

The existing literature from the U.S. and around the world is still inconclusive as to whether bus lanes promote street safety. Furthermore, there is evidence that how they are implemented has a pronounced effect on outcomes. Installing bus lanes in the offset or center lane, painting the lane red, reducing the number of traffic lanes, and shortening crosswalks all made streets safer. This study seeks to add to the existing body of research by considering if there is a difference in street safety between peak hour and all-day bus lanes, and if these differences can be explained by how they were accommodated. To analyze this relationship, I take a similar approach as many of the aforementioned studies (SFMTA, n.d.; Halls, 2021; Tse, et al, 2012; Gitelman, et al, 2020) and conduct a before-and-after comparison of streets and their respective bus lane type.

Methodology

This study examines if there are differences in traffic collisions among streets with streets with all-day bus lanes, peak hour bus lanes, and no bus lanes. Can these differences be explained by the trade-offs made to accommodate each bus lane type? By analyzing these three street types we learn how traffic collisions change as street designs increasingly accommodate bus lanes— from none to fully and all-day. Peak hour and all-day bus lanes often incorporate different designs to their installations. Understanding the relationship between each bus lane type and collision trends sharpens our understanding of how they can be better installed to promote street safety. I focus on four Los Angeles bus lanes – three are peak hour lanes and one operates all-day. The endpoints and installation dates of the four bus lanes are listed in Table 1.

Table 1: Sample of City of Los Angeles Bus Lane Streets

Street	Endpoints	Installation Date	Type of Bus Lane
Wilshire Blvd.	South Park View St. & Western Ave.	June 2013	Peak Hour
	Western Ave. & San Vicente Blvd.	April 8, 2015	Peak Hour
	Whittier Dr. & Comstock Avenue	April 8, 2015	Peak Hour
	Selby Ave. & Veteran Ave,	April 8, 2015	Peak Hour
	Bonsall Ave. & Federal Ave.	April 8, 2015	Peak Hour
	Federal Ave. & Centinela Ave.	Nov. 16, 2015	Peak Hour
Sunset Blvd/Cesar E Chavez Ave.	Figueroa St. & Innes Ave.	Summer 2013	Peak Hour
Figueroa St.	Figueroa Wy. & 6th St.	October 2012	Peak Hour
Figueroa St.	Figueroa Way & 6th St.	August 30, 2018	All-day

Wilshire Boulevard is broken up into segments because the bus lane on this corridor is not consistent and is only installed between the identified streets. The different segments were also installed in phases and require different study periods in order to truly understand shifts in collisions that coincide with bus lane installation.

Each of the peak hour bus lane study streets has a unique traffic flow and bus lane implementation. Wilshire Blvd is a bidirectional corridor with a bidirectional bus lane. Sunset Blvd is a bidirectional corridor, but its bus lane only runs eastbound (EB) in the AM and westbound (WB) in the PM. Figueroa St transitions from a bidirectional to a one-way corridor, and its bus lane only runs northbound (NB). Due to each bus lane's unique characteristics, I divide them into distinct models. The details for the four bus lane models are summarized in Table 2

Table 2: City of Los Angeles Bus Lane Models

Street	Endpoints	Installation Date	Type of Bus Lane	Traffic flows	Bus Lane Travels
Model 1					
Wilshire Blvd.	South Park View St. & Western Ave.	June 2013	Peak Hour	Bidirectional	Both directions (AM & PM)
	Western Ave. & San Vicente Blvd.	April 8, 2015	Peak Hour	Bidirectional	Both directions (AM & PM)
	Whittier Dr. & Comstock Avenue	April 8, 2015	Peak Hour	Bidirectional	Both directions (AM & PM)
	Selby Ave. & Veteran Ave,	April 8, 2015	Peak Hour	Bidirectional	Both directions (AM & PM)
	Bonsall Ave. & Federal Ave.	April 8, 2015	Peak Hour	Bidirectional	Both directions (AM & PM)
	Federal Ave. & Centinela Ave.	Nov. 16, 2015	Peak Hour	Bidirectional	Both directions (AM & PM)
Model 2					
Sunset Blvd/Cesar E Chavez Ave.	Figueroa St. & Innes Ave.	Summer 2013	Peak Hour	Bidirectional	EB (AM) & WB (PM)
Model 3					
Figueroa St.	23rd St. & 6th St.	October 2012	Peak Hour	Bidirectional and one-way	Only NB (AM & PM)
Model 4					
Figueroa St.	23rd St. & 6th St.	August 30, 2018	All-day	Bidirectional and one-way	Only NB (AM & PM)

For the streets with no bus lanes, I look at two streets that the Los Angeles Department of Transportation (LADOT) and the Los Angeles County Metropolitan Transportation Authority (LA Metro) have identified as candidates for new installed bus lanes by Spring 2022 (Linton, 2021). The streets and their endpoints are listed in Table 3.

Table 3: Sample of City of Los Angeles Streets with No Bus Lanes

Street	Endpoints
La Brea Ave.	Pico Blvd. & Sunset Blvd.
Alvarado St.	Beverly Blvd. & Sunset Blvd.

These segments will inevitably be part of a larger bus lane corridor. These particular endpoints were chosen because they form a segment that share similar characteristics to specific streets that already have bus lanes. For example, the specified segment of La Brea Avenue is 3.6 miles, seven lanes, and has a speed limit of 35 miles per hour (City of Los Angeles, 2020). The corridor area is lined with commercial land uses and has a mix of single-family and mid-density residential housing. Similarly, Wilshire Boulevard between Western Avenue and San Vicente Boulevard, where a bus lane has been running since 2015, is also 3.6 miles, seven lanes, and has a speed limit of 35 miles per hour (City of Los Angeles, 2020). The segment is lined with commercial uses and single-family and mid-density residential housing in its vicinity. Matching street characteristics will ensure that it will be reasonable to compare collision data between these pair of streets and consider how the inclusion of a bus lane played a factor in any observed differences.

For this study, I take a similar approach to past research that has considered bus lanes and traffic safety by comparing streets before-and-after bus lane installation in order to understand their influence (SFMTA, 2017; Halls, 2021; Tse, et al, 2012; Gitelman, et al, 2020). A strength of this approach is it allows for a longitudinal study of the same street with one of the biggest differences being the introduction of a bus lane. It allows us to understand how collision frequencies and types shifted, or not, after the bus lane was installed. To understand this association, I quantitively analyze crash data from RoadSafe GIS, a traffic collision database. Through RoadSafe GIS, I searched for "All Collisions" on a given street between the endpoints. My search query excluded the 3-months before-and-after installation of the bus lanes to not include data that may be skewed from 1) the installation period when construction may have created traffic hazards, 2) the post-installation period when users were getting accustomed to the infrastructure. I used the approximate start date of the COVID-19 pandemic (March 2020) as a cutoff for my data assembly. Travel behavior during the COVID-19 pandemic, especially its early months, was low and differed greatly from traditional patterns. Including data from the pandemic could risk the reliability of any correlations found on the study segments. I analyzed between 15 months and twelve years of data, depending on the installation date. The temporal periods for each bus lane in the study is shown Table 4.

Table 4: City of Los Angeles Bus Lane Models with Study Time Periods

Street	Endpoints	Before Temporal Period	Installation Date	After Temporal Period	Type of Bus Lane
Model 1					
Wilshire Blvd.	South Park View St. & Western Ave.	Sept. 2006-Mar. 2013	June 2013	Sept. 2013-Mar. 2020	Peak Hour
	Western Ave. & San Vicente Blvd.	May 17, 2010 – Jan 8., 2015	April 8, 2015	July 8, 2015-Mar. 2020	Peak Hour
	Whittier Dr. & Comstock Avenue	May 17, 2010 – Jan 8., 2015	April 8, 2015	July 8, 2015-Mar. 2020	Peak Hour
	Selby Ave. & Veteran Ave,	May 17, 2010 – Jan 8., 2015	April 8, 2015	July 8, 2015-Mar. 2020	Peak Hour
	Bonsall Ave. & Federal Ave.	May 17, 2010 – Jan 8., 2015	April 8, 2015	July 8, 2015-Mar. 2020	Peak Hour
	Federal Ave. & Centinela Ave.	Aug. 2, 2011-Aug. 16, 2015	Nov. 16, 2015	Feb. 16, 2016-Mar. 2020	Peak Hour
Model 2					
Sunset Blvd/Cesar E Chavez Ave.	Figueroa St. & Innes Ave.	Dec. 2006-Mar. 2013	Summer 2013	Dec. 2013-Mar. 2020	Peak Hour
Model 3					
Figueroa St.	23rd St. & 6th St.	July 2008-2012	October 2012	Jan. 2013-2017	Peak Hour
Model 4					
Figueroa St.	23rd St. & 6th St.	Feb. 28, 2017-May 30, 2018	August 30, 2018	Nov. 30, 2018-Mar. 1, 2020	All-day

For the streets with no bus lanes, I used the same temporal period as their paired street to measure them and compare them to the bus laned street. In the case of La Brea Avenue, I compared collisions during the same windows of time as the Wilshire Boulevard Western-San Vicente bus lane. For Alvarado Street, I used the same windows of time as the Sunset Boulevard Figueroa-Innes bus lane.

Table 5: Study Time Periods of City of Los Angeles Streets with No Bus Lanes

Street	Endpoints	Before Temporal Period	After Temporal Period
La Brea Ave.	Pico Blvd. & Sunset Blvd.	May 17, 2010 - Jan 8., 2015	July 8, 2015-Mar. 2020
Alvarado St.	Beverly Blvd. & Sunset Blvd.	Dec. 2006-Mar. 2013	Dec. 2013-Mar. 2020

For my analysis, I used STATA to calculate descriptive statistics and understand changes in the number, type and characteristics of traffic collisions before and after bus lane installation. Collisions on both sides of the street were accounted for, even for the bus lanes that were unidirectional. The reason is that users experience roads holistically. Having one less lane on a street alters the behavior of its drivers, which influences how all users on the road feel while using the street. I specifically focus on five collision metrics as safety indicators:

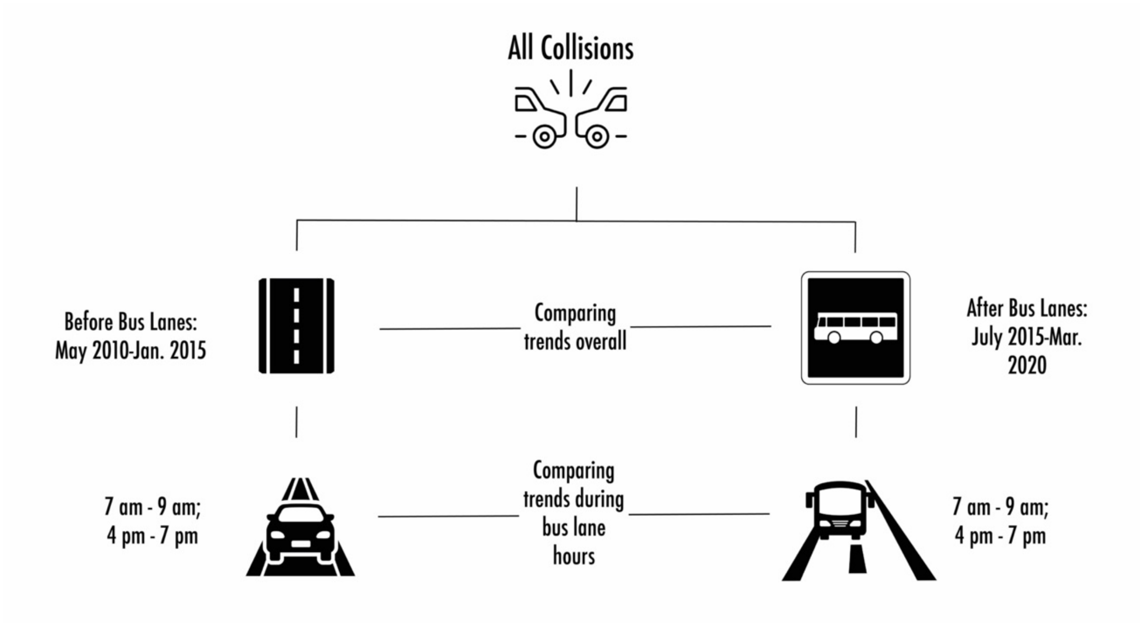
- Collisions
- Fatal Collisions
- Severe Collisions
- Pedestrian-involved Collisions
- Bicyclist-involved Collisions

I examined fatal and severe collisions because addressing them is a tenet of Los Angeles' Vision Zero program (LADOT, n.d.). I examined pedestrian and bicyclist-involved collisions because these users represent a disproportionate percentage of traffic deaths, making them the most at-risk users on the road (LADOT, 2017). Reductions in these metrics implies a safer street. Before analyzing the data, I omitted any collisions with a collision time of 2500 hours. Collision times are recorded using military time (0 to 2400 hours). 2500 is an incorrect entry. The time of the collision is central to the study in order to understand how collisions are changing in relation to operating bus lane hours.

My analysis begins by comparing the two temporal periods, before bus lane installation and after bus lane installation, with the above safety metrics. Then, I isolate peak and bus lane hours to do a targeted comparison of the same periods: before and after bus lane installation. For example, how do collisions during Wilshire's bus lane hours

(Monday-Friday, 7 am - 9 am and 4 pm - 7 pm) compare to the same days and times when there wasn't a bus lane? Did traffic collisions decrease during the bus lane hours? If so, how does it compare to overall changes in collisions on the corridor?

Figure 1: Methodology Example: Wilshire Blvd Bus Lane Between Western Ave and San Vicente Blvd



I conclude with a qualitative analysis of the corridors with the highest increase and decrease in collisions. By conducting a site visit to each corridor, I assessed the street design elements, and any tradeoffs made to accommodate the bus lanes that may have attributed to the corridor's enhanced or diminished safety. I conducted site visits along both corridors during the same hours of lane operation. Elements assessed included the corridor's stress level (the level of discomfort users experience on the street), areas of conflict, bus lane obstructions, bus lane violations, speeds, and travel behavior.

This research design posed a number of difficulties. One, it is difficult to isolate other changes on the streetscape that may influence traffic safety (e.g., improved street lighting, changes in the speed limit, turn signals, etc.). It is also difficult to measure how much the bus lane is responsible for any change in traffic safety. Thus, I underscore that this is not a study of causation. Lastly, due to the fact that bus lanes installations in Los Angeles happened relatively recently, there is only a small number of streets with enough data to draw meaningful analysis. Leaning on a small group of streets could skew findings towards outcomes that are specific to those streets, and not to their respective bus lane type. Nevertheless, it is essential to monitor collision patterns on bus laned streets, however small the sample, to further their application on LA streets, strengthen safety, and avoid exacerbating the disproportionate danger the current roadway poses to Black and Latinx pedestrians (Brozen & Ekman, 2020). My hypothesis is that bus lanes help reduce traffic collisions, and thus, create a safe street environment for all users. Much like road diets which repurpose space on the street for non-vehicle usage, bus lanes restrict the use of single-occupancy vehicles on a street. This reduction in lanes results in lower vehicle speeds which is associated with fewer collisions and safer streets.

The Dodger Stadium Express

A note on a unique element on the Sunset Blvd bus lane. The Dodger Stadium Express is a bus that loops between Union Station to Dodger Stadium, routing though the Sunset Blvd bus lane segment. Since 2010, the Dodger Stadium Express has been running before, during, and after Dodger home games. In 2015, the Express received improvements including a dedicated bus lane with cones and enforcement officers (LACMTA, 2019). Since the Dodger Stadium Express is a bus lane with no consistent schedule and its improvements do not match the established study periods, including them would have disrupted the established non-bus lane and bus lane hour categories. Thus, I distinguished these collisions from the collision data on Sunset Blvd. I did so by cross-referencing every collision date and time with the Dodger home game schedule from 2010-2019 (Baseball Reference, n.d.). To estimate the window of time the Express operated and if a collision had to be dropped, I used the average length of a game (Associated Press, 2019), the 90 minutes the shuttle runs before games, and the 45 minutes it runs after games (MLB, n.d.). Once these incidents were dropped, I carried out my analysis as described.

Figure 2: Location of Study Streets

Case Studies

A case study analysis of three U.S. bus lane programs offer a better understanding of the type of provisions and policies cities have adopted to balance safety and transit efficiency on bus lane corridors. Per recommendations from LADOT, the three cities analyzed were New York City, San Francisco, and Seattle. For each city, I give background on their bus lane program. I then highlight accommodations and design elements that are either prevalent or unique compared to the other case study cities. A comparison of the bus lane accommodations from each city and Los Angeles is summarized at the end of this section.

New York City

New York City (NYC) has the most extensive bus lane network in the country. As of May 2021, there were 138 miles of bus lanes on New York City streets (Hu and Goldbaum, 2021). It is difficult to categorize NYC bus lanes neatly into curbside, offset, and busways (streets that are entirely dedicated to buses) because they use different strategies based on what the conditions can accommodate. For example, the M14A/D Bus Priority is curbside for four segments, a busway for one segment, and offset for two segments. Other vehicles may enter a bus lane for no more than one block but must either: turn into a driveway, make the next available right turn, or "quickly drop off or pick up passengers" (NYCDOT, n.d.a). Bicyclists are typically not allowed in the bus lane, but some projects incorporate designs such as sharrows that signal shared use is allowed (NYCDOT, 2021a). Bus lanes are enforced by the New York Police Department and cameras. In 2010, New York State Governor David Paterson signed legislation allowing either fixed cameras or cameras on buses to carry out enforcement (NYCDOT and MTA, 2012a). In 2022, New York City Department of Transportation (NYCDOT) is expected to add fixed bus lane enforcement cameras on up to 15 corridors (NYCDOT, 2021b).

Most of the bus lanes from the past fifteen years were created under the Select Bus Service (SBS) program. SBS is a collaboration with the NYCDOT and Metropolitan Transportation Authority that started in 2008. In 2019, the Better Buses Action Plan set the Action Plan Goals of (NYCDOT, 2019):

- increasing bus speeds by 25% at the end of 2020,
- improving five miles of existing bus lanes/year,
- installing 10-15 miles of new bus lanes/year,
- piloting up to 2 miles of separated bus lanes in 2019.

NYC's bus lanes incorporate a variety of designs and street configurations to accommodate the bus. As part of the Select Bus Service program, bus lane designs incorporate (NYCDOT, 2019):

- red paint
- transit signal priority
- off-board fare payment machines
- enhanced bus stops with large shelters
- high-capacity, low-floor buses

The 2019 Better Buses Action Plan expanded on these designs with additional tools including (NYCDOT, n.d.a):

- protected bus lane barriers
- bus boarders (expanded curb pedestrian space for safer boarding)
- bus queue jump signal
- curb management (discussed below)

- turn restrictions

Design

NYC bus lanes use unique design elements that improve safety and bus performance such as red thermoplastic paint, curb management, turn restrictions, busways, and off-board fare payment machines.

Red painted lanes

Red thermoplastic paint is a design element in most bus lanes in NYC. In 1982, the city started a pilot project where it installed red thermoplastic strips along ten bus lanes in Manhattan. (Goldman, 1982). In 2008, the Select Bus Service program made red paint a common design feature on bus lanes. A study in 2012 found that 44% of bus lane miles were painted red, with red offset lanes increasingly replacing curbside white lanes (Safran, et al, 2014). A review of recently installed and forthcoming bus lanes show red painted lanes as fixtures in their designs (NYCDOT, n.d.b) (NYCDOT, n.d.c).

The 5th Avenue Busway crossing W 51st Street in Manhattan. Source: NYCDOT, 2021c

A 2014 study of 61 bus lane segments in NYC found that offset lane configurations with red markings increases bus lane use and throughput and reduces bus lane obstruction compared to curbside, white-marked lanes (Safran, et al, 2014).

Curb management

Curb management is a critical component to bus lane implementation in NYC. The high density of storefronts and vehicle traffic make curb space for deliveries a common concern among business owners on bus laned corridors (NYCDOT, 2021a) (NYCDOT, 2022a) (NYCDOT, 2022b). In addition, community input frequently echoes concerns over parking loss (NYCDOT, 2022a). To address the needs of stakeholders while accommodating the bus lane, NYCDOT implements a variety of curb management strategies. Curbs on bus lane corridors may have one or a combination of the following restrictions (NYCDOT and MTA, 2012b):

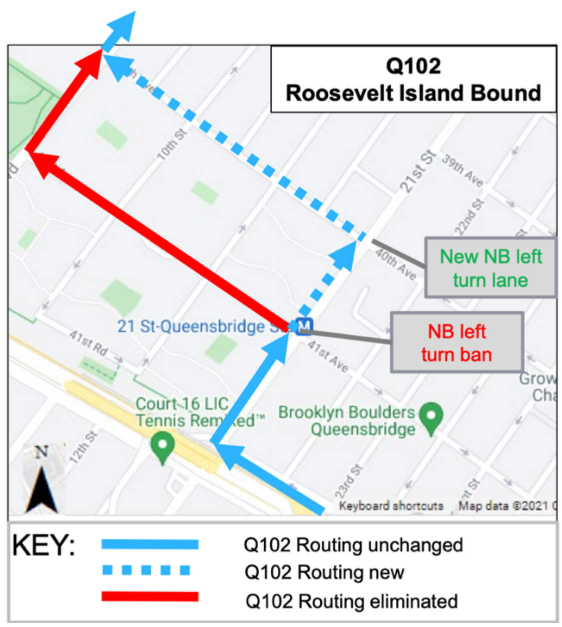
- No parking
  - dropping-off/picking up passengers okay
  - unloading/loading of packages okay
  - no parking
- No standing
  - dropping-off/picking up passengers okay
  - no unloading/loading of packages
  - no parking
- No stopping
  - no pickup/drop-off
  - no load/unloading
  - no parking
  - no stopping or waiting anytime
- Commercial loading zones
  - commercial vehicles can load/unload
  - commercial vehicles can park for limited time (to encourage turnover)
  - no standing to all *noncommercial* vehicles
- Special zones
  - Specifically tailored curb management strategies based on the surrounding land use
  - For example:
    - Delivery zones on select curbs, all day or midday
    - Neighborhood Loading Zones: commercial loading zones on targeted blocks during business hours, Monday-Friday. A delivery occurring on an adjacent block would have to park in the Neighborhood Loading Zone and walk to deliver the package (NYCDOT and MTA, 2022c)

These strategies can be enforced for part or all of the day. For example, The Nostrand Ave-Rogers Ave SBS proposes delivery zones with alternating windows to allow deliveries and reduce double-parking (NYCDOT and MTA, 2012c). Delivery windows are 10 am – 12 pm on the east curb and 12 pm – 2 pm on the west curb, with special exceptions on site-specific curbs that require part of the curb available for deliveries all day (NYCDOT and MTA, 2012c).

The First and Second Avenues SBS is a curbside peak hour bus lane that run on a one-way street. Because of its one-way traffic flow, only one lane is needed for the bus lane, leaving the other curb available for deliveries. Parking is allowed 7 pm – 7 am on weeknights and all day on weekends when most businesses are not accepting deliveries (NYCDOT, n.d.d). Other projects use an offset bus lane configuration to better manage the curb. For example, the 34th Street SBS shifted its bus lane to the offset lane, opening up the curb and expanding its loading zone from 32 to 258 spaces with a loading zone on every block (NYCDOT and MTA, 2011). Strategic curb management ensures bus lanes are not obstructed while maintaining corridor access for private and delivery vehicles.

Left Turn Restrictions

Left turns are associated with high rates of pedestrian injuries (NYCDOT, n.d.e). NYCDOT's Pedestrian Safety Study found that three times as many pedestrians were killed or seriously injured in left turn crashes compared to right turn crashes (NYCDOT, 2010). SBS projects often impose left-turn restrictions either at key intersections or throughout the corridor. For example, the 21st Street Transit Priority project found that the most common pedestrian injury was left turn vehicles striking pedestrians crossing with the signal. To address this, left turns bans were installed at key intersections and left turn lanes were installed at other intersections to facilitate throughput (NYCDOT and MTA, 2022c).



The 21st Street Transit Priority and Safety Project adjusts left turns on its corridor to improve traffic safety. Source: NYCDOT and MTA, 2022c

The Jamaica Ave and Archer Ave busway restricts left turns except at one intersection (Vision Zero, NYCDOT, and MTA, n.d.). The Downtown Flushing Main St Busway restricts left turns except for buses and for all vehicles at 41st Ave (NYCDOT and MTA, 2021a). Limiting left turns reduces the need for sudden lane changes by cars stalled behind other cars waiting for an opportunity to turn. Road designs can discourage frequent lane changing or weaving to increase traffic safety (NYCDOT, 2010).

Busways

Busways allocate the entire street to buses. Other vehicles are given only local access to busways and trucks can occasionally drive through on busways, depending on restrictions. Cars and commercial vehicles can have local access to one block, but then must make the next legal turn to avoid a bus lane violation (NYCDOT, n.d.f). There are seven total busways in NYC, with an eighth one in development that will include expanded bike and pedestrian space on almost twenty blocks (NYCDOT, n.d.g). Busways can be in effect all day or part of the day. The 14th Street Busway is only in effect between 6 am – 10 pm (NYCDOT, n.d.e). Outside of busway hours, all vehicles can make through trips on the corridor. Conversely, the Downtown Flushing Main St Busway is in effect 24 hours a day, seven days a week (NYCDOT and MTA, 2021a). The Downtown Flushing Main St Busway does so while still being sensitive to the needs of those that work and live along the corridor. The busway alternates between the curb and offset lane, depending on parking restrictions (NYCDOT and MTA, 2021a). Commercial metered parking is in effect along the corridor before noon to offer designated space for deliveries and encourage turnover and keep passenger parking available when it is in high demand (NYCDOT and MTA, 2021b). Recent crash data indicates that the Downtown Flushing Main St Busway has improved safety (NYCDOT and MTA, 2021b). Initial reports show pedestrians feel safer, walking is "more pleasant" and crossing the street is easier (NYCDOT and MTA, 2021b).

Off-board fare payment machines

Off-board fare payment machines have been on SBS routes since 2009 (NACTO, 2017). Before boarding a bus, riders must pay their fares at an SBS machine located near the stop. Payments can be made with a MetroCard or through the coin machine. A receipt will be provided as proof of payment. Riders can board through any of the bus's doors.

SBS off-board ticket vending machine. Source: NACTO, n.d.

Receipts may be requested upon boarding by Metropolitan Transportation Authority inspectors. Riders without a receipt will be subject to a $100 fare evasion summons (NYCDOT, n.d.h). The off-board payment system has resulted in a decrease in boarding times and an increase in ridership (NACTO, 2017). Regular front-boarding payments take 5-9 seconds per passenger, resulting in longer dwell times and slower bus service (NACTO, 2017).

San Francisco

Transit-Only Lane (TOL) miles in San Francisco have increased substantially in the past few years, but TOLs were first introduced in the city almost 50 years ago. In 1973, the Board of Supervisors of the City and County of San Francisco adopted the Transit-First Policy. Its purpose was to "develop a preferential transit street system" to expedite transit service on specific "transit streets" with the goal of (Transit-First Policy, 1973):

- reducing traffic congestion
- reducing air pollution
- increasing transit efficiency
- encouraging transit use

The policy proposed the following recommendations:

- Exclusive bus lanes

- Restriction of automobile turning movements which conflict with transit vehicles
- Transit-signal priority
- Strict enforcement of double-parking on “transit streets”
- Curb extensions for buses to pick up passengers without leaving the travel lane (Transit First, 1973)

The first TOLs were installed in the 1970s on Judah Street. Source: von Krogh, 2018

Most of San Francisco’s early TOLs used basic design elements such as painted messages and posted signs (SFMTA, 2016). In 2013, SFMTA’s first red-thermoplastic painted TOL was installed on Church Street (SFMTA, 2017). By 2019, San Francisco had more than 43 miles of TOLs (Fowler, 2019).

In the midst of the COVID-19 pandemic, the SFMTA Board approved eight Temporary Emergency Transit Lanes (TETL) to mitigate possible viral exposure by using TOLs to reduce crowding and trip time (SFMTA, n.d.a). Six of the eight TETL projects have been made permanent. From Summer 2020 to October 2021, nearly 14 TOL miles were either upgraded or newly installed, making it the fastest expansion of transit lanes in the city’s history (Rhodes, 2021).

Typically, TOL-use is exclusive to transit, taxis and emergency vehicles (SFMTA, Muni Tips, n.d.). Private vehicle drivers, bicyclists, and rideshare drivers (such as Uber and Lyft) may not drive through a TOL; but they may access a TOL to turn into a business or onto the next street (Fowler, 2019). There are exceptions to these rules. Taxis are not allowed on the Powell Street TOL (DataSF, n.d.). and bicyclists are allowed on parts of the O’Shaughnessy/Masonic TETL (SFMTAB, 2022). TOL operating times vary from Monday-Friday during morning peak hours or business hours to 24 hours, seven days a week (“full time”) (DataSF, n.d.).

Historically, San Francisco Police Department enforced moving and parking violations on TOLs (Fowler, 2019). In 2008, the San Francisco Metropolitan Transportation Authority (SFMTA) started the Transit-Only Lane Enforcement (TOLE) pilot program. The pilot uses cameras on buses to cite cars illegally parked or stopped on a dedicated transit lane. The TOLE program has resulted in few repeat offenders, indicating that driver behavior has adjusted (SFMTA, n.d.c). Of the citations issued between March-August 2012, only 2% received another TOLE citation during the same period in 2013, and only 1% received a TOLE citation in the same 2014 period (SFMTA, n.d.c). A 2017 report found that 67% of TOL citations were issued to rideshare drivers (Bourne, 2018). SFMTA is considering revising the program to allow for citation of driving in transit-only lanes (SFMTA, n.d.c). Citations would be administered as parking tickets, not moving violations, resulting in a less severe penalty while still ensuring dedicated lanes are clear for transit users (SFMTA, n.d.c).

Intersection of O'Farrell and Franklin Street in San Francisco. Source: Wambeke and Wambeke, 2016

Design

San Francisco incorporates design elements to enhance the effectiveness and safety of their TOL projects. Much like New York City - red painted transit lanes, management of turn lanes, and curb management are key components of their corridors. These components, though, are sometimes adopted in ways different than New York City – offering new perspectives to design safe and efficient bus lanes.

Red painted lanes with dashed lines

Red paint is a consistent component of San Francisco TOLs. SFMTA's first red-thermoplastic painted TOL was installed in Spring 2013 (SFMTA, 2017). Through Fall 2016, approximately 10 miles of TOLs were painted red. Many lanes adopt a unique dashed red TOL design to signal to cars where it is ideal to cross to prepare to turn or access driveways (SFMTA, 2017).

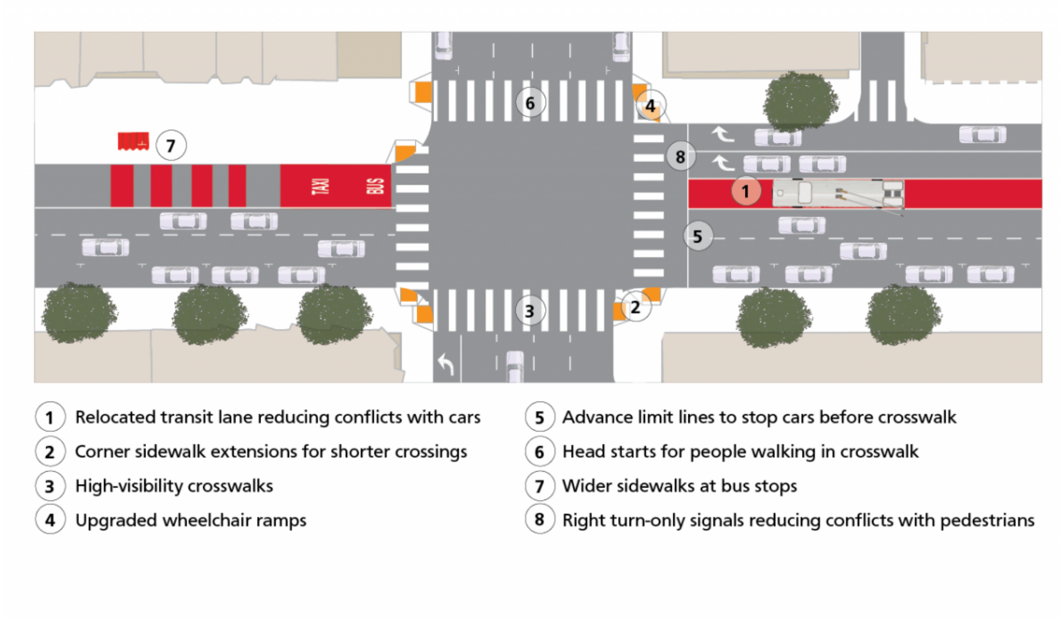
O'Farrell and Cyril Magnin Street in San Francisco. Source: SFMTA, 2017

The painted dash is based on the Federal Highway Administration's recommendation for green bike lane designs (SFMTA, 2017). TOLs like O'Farrell, 14 Mission St Rapid Project, and Geary Rapid Project all adopt the dashed design at specific areas of their corridors (SFMTA, 2017) (SFMTA, n.d.d) (SFMTA, n.d.e). Observations done by SFMTA indicate that most drivers understand and use the dashed red TOLs as intended (SFMTA, 2017). Ninety-three percent (93%) of cars making right turns on O'Farrell did so from the dashed red TOL (SFMTA, 2017). But even red painted bus lanes without the dashed lines experienced benefits. A study by SFMTA found that red painted lanes had the strongest effect on compliance, improving rates by 32% (SFMTA, 2017). After the bus lane on Church Street was painted red, it saw a 14% decrease in travel time and roughly a 50% decrease in transit lane violations, indicating that red paint is an effective passive enforcement strategy (SFMTA, 2015). The extent of the compliance rate, though, is contingent on the operating environment of the corridor. A comparison of three red-treated TOLs saw high compliance rates, but variability of up to 7%-26%, indicating that corridor location and associated traffic has a strong influence on compliance outcomes (SFMTA, 2017). In contrast, the 1 California Temporary Transit Emergency Lane (TETL) is a TOL that is not painted red due to its temporary installation (SFMTA, n.d.f). An analysis of the project found that compliance is an issue and was in need of improvement, specifically as it pertained to parked private and rideshare vehicles (SFMTA, 2021a) (SFMTA, n.d.f). The Mission St SoMA TETL, another project with no red treatment, saw double-parking citations more than double after installation (SFMTA, 2021b). These two TETL further support that red paint encourages compliance. Compliance directly supports street safety. Maintaining orderly traffic flows that minimize sudden and frequent vehicle movements fosters a predictability that results in fewer collisions. As such, injury collisions along O'Farrell, Geary and 3rd Street decreased 24%, while citywide collision trends were nearly unchanged (SFMTA, 2017). San Francisco's new Van Ness Improvement Project adopts a different approach to its red lanes. Instead of red paint, the project uses red concrete for increased durability (Rogozen, 2021) (Cordoba, 2021). The project also used color hardener techniques, making it more durable than an airplane runway (Rogozen, 2021).


The Van Ness Bus Rapid Transit bus lanes. Source: Gravener, 2022

Right turn pockets

Right turn pockets organize travel lanes into designated uses to ensure bus throughput is not delayed by turning vehicles. For example, the 3rd Street TOL operated in the curbside lane and was blocked during rush hour by vehicles in queue to turn right (SFMTA, n.d.g). To address this, the 3rd Street Transit and Safety Project moved the TOL to the second offset lane and installed right turn lanes at three key intersections (SFMTA, n.d.g). Right turn only signals were also installed to reduce conflicts among users (SFMTA, n.d.g).



3rd Street Transit and Safety Project design. Source: SFMTA, n.d.g

The 14 Mission St Rapid Project also includes right turn pockets (SFMTA, n.d.h). Project outcomes include 81% of transit riders and local pedestrians expressing feeling either more or equally safe post-project installation (SFMTA, n.d.h).

It is worth highlighting that this design element is only achievable with an offset-running bus lane. By not occupying a curbside lane, cities have the versatility to use the curbside lanes to meet a variety of needs be it for loading, parking, or turning.

Curb space management

The curb is the most coveted and contested space on the street (Grabar, 2018). Competing interests among transit vehicles, private vehicles, delivery drivers, and rideshare drivers requires San Francisco to strategically manage their curb on TOL corridors. After local merchants expressed concerns about loading and parking along the 1 California TETL, the project removed 9 am – 10 am from its proposed transit lane hours to accommodate parking and loading (SFMTA, 2021c). Overall, SFMTA found that the project did not substantially impact loading availability on the corridor (SFMTA, 2021a). Depending on the block, the Mission Street SoMa Transit Improvement project allows parking and loading on one side of the street, and removed parking and loading on the other side of the street (SFMTA, 2021b). Such compromise resulted in a TOL project that yielded a 60% decrease in vehicular collisions and 40% decrease in pedestrian-involved collisions. The Better Market Street busway project prohibits private vehicles but allows commercial vehicles at specific segments to access loading zones. Still, loading zones on the southern side of Market Street are prohibited during morning peak hours to accommodate high bicycle traffic (Better Market Street, n.d.). Additionally, over 100 new passenger and commercial loading zones were installed on side streets near Market to meet the needs of merchants and rideshare users (Better Market Street, n.d.). Such accommodations make the main corridor available for TOLs while still supporting the interests of multimodal users and business owners. The Geary Rapid Project responded to merchant concerns by moving its TETL from the curbside to the offset lane to increase parking and loading availability (SFMTA, n.d.e). Since some parking space was being converted to loading zones, the city added evening and Sunday afternoon metering to encourage turnover and make parking easier for visitors (SFMTA, n.d.i).

Geary Boulevard is one of a few studied SFMTA TOLs that changed from being curb or center-running to offset-running in order to mitigate traffic impacts and allow for more versatile uses of the curb. This supports research that suggests that offset lanes best balance transit, pedestrian, and traffic needs (Beaton, et al).

Center-running transit lanes call for a drastic reconfiguration of traditional traffic flows, calling for extensive and expansive design work and longer construction periods (SFMTA, n.d.j) – both of which delay project benefits. They also may lead to competing transit traffic flows between rapid and local buses - with BRT getting stuck behind frequently stopping local transit, and local transit having to forfeit stops to accommodate BRT schedules. The offset-running TOL offers comparable travel time savings and reliability as curb or center-running TOL, in a way that is more cost effective (SFMTA, n.d.j) and meets the needs of other users of the corridor.

Seattle

Seattle transit lanes are installed to improve bus speed and reliability, address climate change and encourage mode shifts (SDOT, n.d.a).
Opportunities for transit lanes are identified using the following metrics: (SDOT, n.d.a)

- Demographics and areas of need
- Passenger trips and passenger loads (or passenger demand)
- Passenger delay
- Travel time variability and reliability

The Seattle Department of Transportation (SDOT) is updating this approach to include more equity-focused criteria (SDOT, n.d.a).

The first “bus only” lane was installed on the West Seattle Bridge in 2000 (King County, n.d.). Initially, Seattle transit lanes incorporated few design elements. For example, the design elements of a 2016 transit lane on Pine Street included a stenciled “bus only” and a bike sharrow in white paint, and installed signage (Packer, 2016). A study found that the bus lane maintained the “status quo” due to its ineffective design and lack of turning restrictions (Packer, 2016). In 2019, the Pine Street bus only lane was painted red (Bergerson, 2019). In 2019, Mayor Durkan announced the City’s intent to paint 90 blocks of new red bus lanes by the end of 2020 (Bergerson, 2019).

Transit lanes can be used by buses, streetcars and bicyclists (SDOT, n.d.a) (Neilson, 2013). Similar to New York and San Francisco, other vehicles may enter the transit lane to turn right or enter a driveway (SDOT, n.d.a).

There are three main types of transit lanes:

- time-restricted bus-only lanes,
- all-day transit lanes
- dedicated transit corridors (or busways)

Time-restricted bus-only lanes are often called Business Access and Transit (BAT) Lanes (SDOT, n.d.a). They typically operate during peak-hours, occupy the curb lane, and are sometimes painted red (King County Metro, n.d.). All-day transit lanes are in effect 24 hours, seven days a week (SDOT, n.d.a). They are usually painted red to signal to drivers that the lane is restricted to transit (SDOT, n.d.a). Dedicated transit corridors are a collection of streets where all lanes are exclusive to transit. Time and curb restrictions vary depending on the corridor (SDOT, n.d.a).

SDOT is currently considering a fourth bus lane typology called a Freight and Bus (FAB) lane (SDOT, n.d.a). These lanes would give exclusive access to freight trucks and transit vehicles during a given time, but would not allow bicyclists (Packer, 2022). A 2020 study found that freight and buses have alternating peak periods, thus, a Freight and Bus lane would not encounter competing interests among users (Urban Freight Lab, 2020).

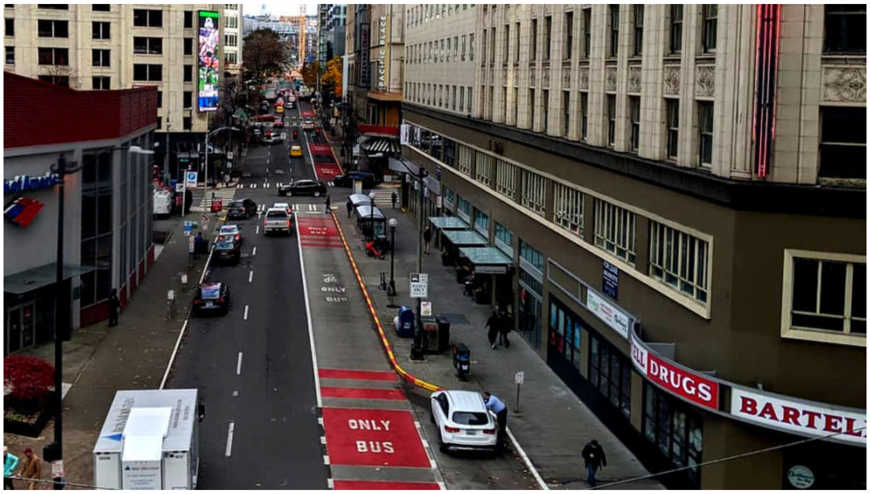
Transit lanes are enforced by the Seattle Police Department and, most recently, traffic cameras (Bergerson, 2019) (Bancroft, 2022). In April 2022, traffic cameras were installed on three Seattle bus lane corridors with three more corridors scheduled for May 2022 (Lindblom, 2022). First-time violators are mailed a warning notice, followed by a fine for each additional offense. The traffic camera pilot is approved temporarily by the state Legislature through mid-2023 (Lindblom, 2022).

Design

Seattle's bus lane designs emphasize striped red paint, transit queue jumps, and mixed bus lane configurations to achieve project goals. Below, I discuss the aforementioned design elements in more detail.

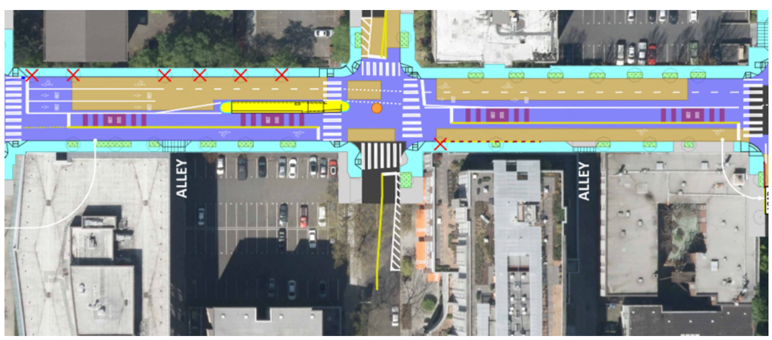
Striped Red Paint

Striped red paint is a common design element on Seattle bus lanes. Instead of painting the entire lane red, Seattle applies striped red paint only to the ends of each block of a bus lane corridor.



Columbia Street bus lane in Seattle. Source: (MyNorthwest Staff, 2022)

The striped red paint is used to discourage idling vehicles from blocking buses (SDOT, n.d.b) and improve road efficiency for all users (SDOT, n.d.c). Painting only the ends of the block reduces project and maintenance costs while still communicating to users the lane is to be used by buses only (StreetsCred, 2019). A methyl methacrylate is used to make its installation more durable than paint, extending the longevity of installation (Bergerson, 2019). Ten out of 20 existing or forthcoming bus lane projects had striped red paint, such as the University District Bus Lane (SDOT, n.d.b) and RapidRide G Line (SDOT, n.d.d).



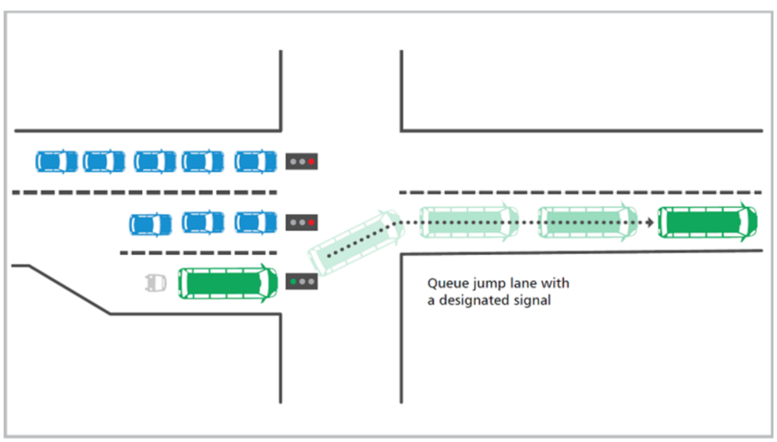
Striped red paint on the project proposal for the RapidRide G Line on Madison Street between 7th and 9th Ave. Source: (SDOT, n.d.e)

Queue Jump

Queue jumps, or bus lane signals, give buses priority at specific intersections (Seattledot, 2020). Buses have a designated signal that allows them to cross an intersection before any other vehicle (Streetfilms, 2016).

Transit queue jump on 128th St SW in South Everett. Source: Fesler, 2018

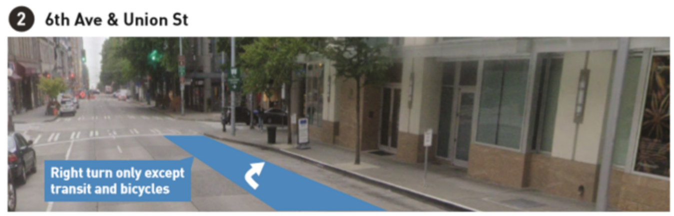
This is often installed at the end point of a bus lane to give buses a clear path to merge back into private vehicle traffic (SDOT, n.d.f). Queue jumps are also installed at specific bus turn signals where turning buses are typically delayed (King County Metro, 2021). The Route 40 Transit-Plus Multimodal Corridor Project is still in the design phase but will include bus lanes along the corridor with a left turn queue jump (King County Metro and SDOT, 2021). The RapidRide J Roosevelt Line will include five different queue jumps (SDOT, 2021). Queue jumps can improve transit travel times by 5%-15% (Kittelson and Associates, 2007).



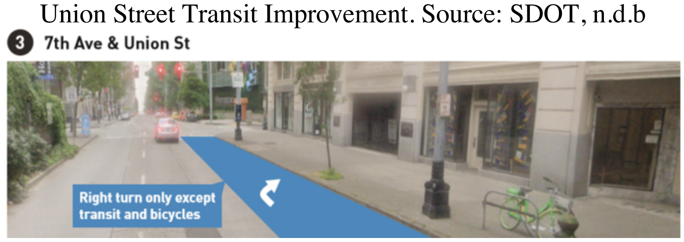
Design of Seattle queue jump. Source: SDOT, n.d.f

Mixed bus lane configuration

Seattle bus lane corridors can shift from being curbside, offset, to center-running on any given block. The mixed bus lane configuration allows the city to accommodate curb demand when appropriate. Of the twenty bus lane projects analyzed, eleven incorporated a mixed design. For example, Phase 1 of the Route 7: Transit Plus Multimodal Corridor project is a mix of curbside and offset running bus lanes (SDOT, n.d.g). This ensures that parking is not reduced in the project area (SDOT, n.d.g). The Union Street Transit Improvements project has a similar configuration. For one block, the bus lane is curbside-running and for another block it is offset to free the curb space for other uses (SDOT, n.d.b).

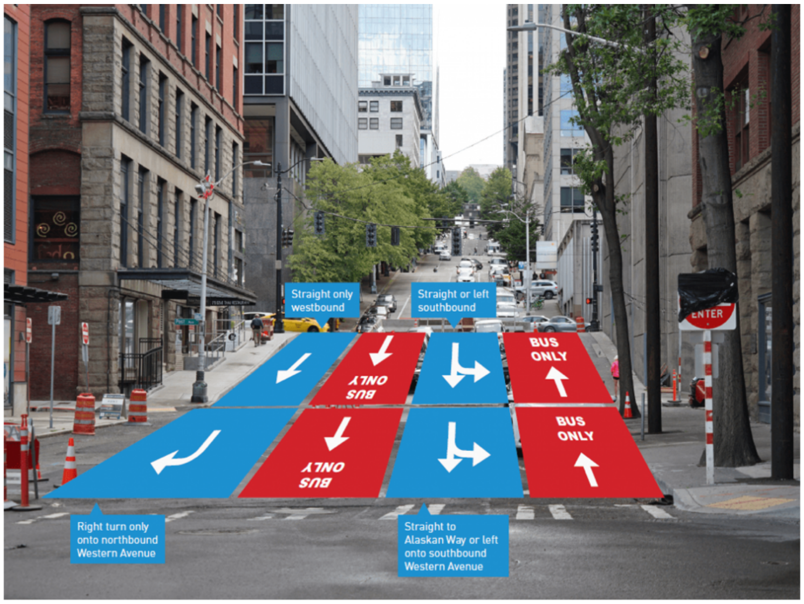


Union Street Transit Improvement. Source: SDOT, n.d.b



Union Street Transit Improvement. Source: SDOT, n.d.b

Other projects blend a curb and center-running bus lanes (SDOT, n.d.h) (SDOT, n.d.b) (Mah, 2016). Sometimes, the bus lane configuration can even differ on the same block. For example, the Columbia St 2-Way Transit Corridor project converted a one-way street into a two-way transit corridor (SDOT, n.d.i). The three northern lanes maintained their westbound flow, with the middle lane being converted into a bus lane (see below). The southernmost lane was converted into a bus lane going in the opposite direction (Turmm, 2020). Such configuration maintains turning lanes for private vehicles that will not interfere with the westbound bus lane right of way. Mixed bus lane configurations allow for bus lanes to run the length of a corridor while being mindful of the specific needs for curbside space on each block.



Columbia Street's one-way street being designed as a two-way transit corridor. Source: Trumm, 2020

Case Study Summary

New York City, San Francisco, and Seattle use bus lane implementation strategies that balance bus efficiency, street safety, and community needs. Red paint, turning management, and curb management are all consistently incorporated into their bus lane designs. Studies in New York City and San Francisco show that red painted bus lanes are an effective tool to improve compliance, furthering street safety (Safran, et al, 2014) (SFMTA, 2017). Streets that did not use red paint such as the 1 California TETL in San Francisco or the Pine St bus lane in Seattle saw conditions either worsen or stay the same. Turning vehicles delay buses, cause traffic, and are a source of traffic violence (Packer, 2016) (NYCDOT, 2010). Better managing turning movements on bus lane corridors affirms street safety. Curb management is a prominent design in New York City and San Francisco bus lanes. Bus lanes that occupy the curbside lane may conflict with other vehicles that expect to have access to the curb. Similarly, all the case study cities illustrate that bus lanes do not have to be tethered to the curb. Offset and center lanes are used in each city to introduce a bus lane and leave the curb open for other uses. Complementary design elements that explicitly communicate to all users how to navigate bus lane corridors should be implemented to enhance street safety.

Below is a summary table that lists all the bus lane design elements discussed in this section. The table shows how Los Angeles compares to the case study cities. Los Angeles' bus lane design elements were considered up until the March 2020, the cutoff date for the collision data for this study. Some design elements like red paint (Linton, 2021a) have been installed on Los Angeles bus lanes since March 2020. Curb management strategies present on bus lanes during the study period were minor, such as the bus lane accommodating parking by operating for one block in the offset lane or only during peak hours.

Table 6: Summary Table of Bus Lane Accommodations in Case Study Cities and LA

	NYC	San Francisco	Seattle	Los Angeles
Bicyclists allowed	⊘	⊘	✓	✓
Local access allowed	✓	✓	✓	✓
Red paint	✓	✓	✓	⊘
Curb management	✓	✓	✓	✓
Turn management	✓	✓	✓	✓
Off-board fare	✓	⊘	⊘	⊘
Busways	✓	✓	✓	⊘
Queue Jump	✓	✓	✓	✓
Mixed bus lanes	✓	✓	✓	✓

Quantitative Analysis

Findings are shared in the form of percentage change of collisions between the before-and-after bus lane installation periods. Data is further disaggregated to isolate the time of day the bus lane will or did operate. Discussions mostly revolve around the five collision metrics that serve as the study's safety indicators:

- Collisions
- Fatal Collisions
- Severe Collisions
- Pedestrian-involved Collisions
- Bicyclist-involved Collisions

These metrics are normalized to help us understand changes in collisions given the installation of a bus lane.

Model 1

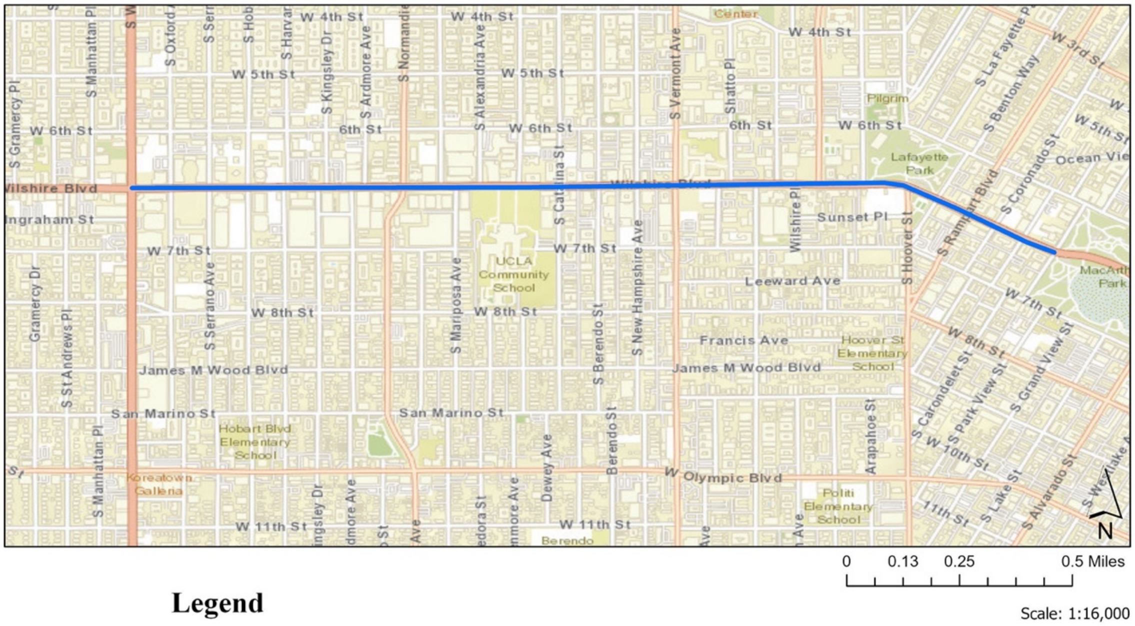
Wilshire Boulevard

The Wilshire Boulevard bus lane is a discontinuous dedicated lane that runs bi-directionally from MacArthur Park, just west of Downtown LA, to the border of Santa Monica and Brentwood. Along its route this dedicated lane is broken up, resulting in six individual segments of bus lanes. The bus lanes on the corridor were installed in three phases, with the earliest segment at Park View Street in MacArthur Park installed in June 2013, and the latest segment at Federal Avenue near Brentwood installed in November 2015. Because of this, I analyzed each of the six segments individually using three distinct before-and-after periods reflecting the installation dates of these projects. All six segments, though, have the same design elements: the bus lane occupies the curbside lane, “Bus Lane” is stenciled on the ground in white paint, and signs throughout the corridor indicate bikes are “ok” in the bus only lane.

Park View Street to Western Avenue

The first phase of the Wilshire Boulevard bus lane was installed between South Park View Street and Western Avenue. The bus lane is 1.76 miles long and runs bi-directionally during morning and evening peak hours.

Figure 3: Wilshire Blvd: Park View St to Western Ave Study Segment



Legend

Wilshire: Park View to Western

Peak-hour Bus Lane

<u>Before Bus Lane Installation (Sept. 2006 -Mar. 2013)</u>

In total, 705 collisions occurred on this street segment. Looking at collisions based on their time of occurrence, I separated collisions that occurred during the peak hours and non-peak hours.

Table 7: Wilshire Blvd: Collisions Between Park View St and Western Ave Before Bus Lane Installation

	Peak hour	Non-peak hour	Total Collisions
Before Bus Lane Installation	156	549	705

Peak hours vs non-peak hours

Collision Severity
Fewer serious collisions occurred during non-peak hours. Four fatalities occurred, three involved pedestrians and one another driver. The most common collision on the corridor

resulted in the second least severe category, “complaint of pain” (see Table 62 in Appendix A).

Parties Involved
Overall, active transportation safety is worse during peak hours but with mixed outcomes when findings are disaggregated by active transportation mode. Pedestrians fared much worse during peak hours, whereas bicyclists fared slightly better (see Table 63 in Appendix A).

Summary
Collisions were more serious during peak hours and involved a higher proportion of pedestrians and drivers, and a slightly lower proportion of bicyclists.

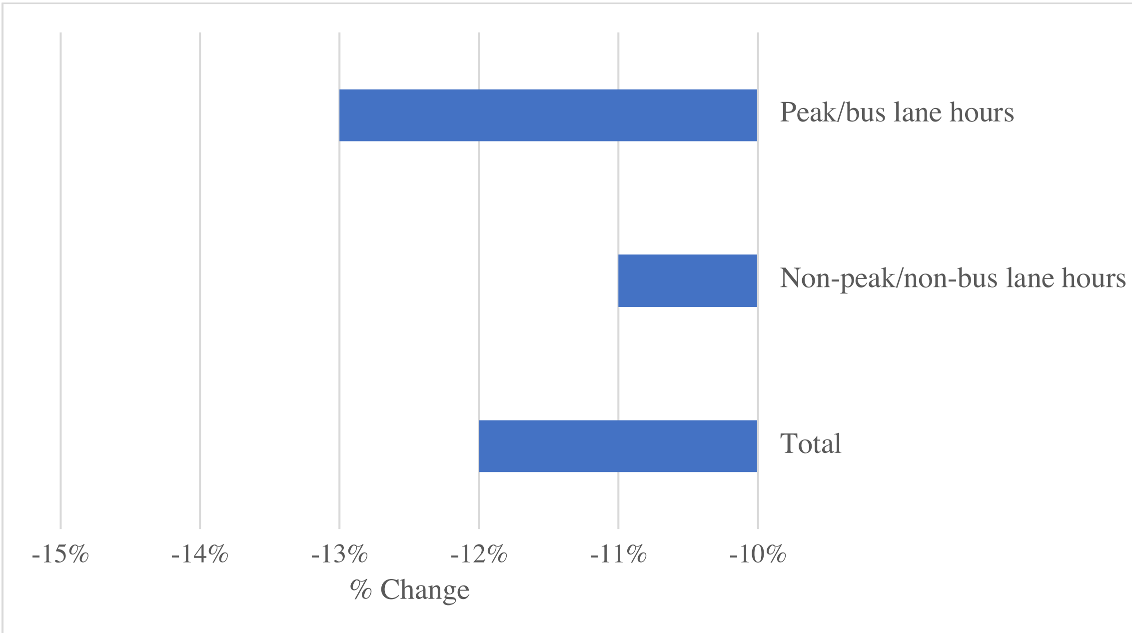
After Bus Installation (Sept. 2013-Mar. 2020)

During the “after” study period, 621 collisions occurred on the bus lane segment. Most notably, collisions decreased at relatively higher rate during bus lane hours.

Table 8: Wilshire Blvd: Collisions Between Park View St and Western Ave Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	156	549	705
After Bus Lane Installation	135	486	621
% change	-13%	-11%	-12%

Figure 4: Wilshire Blvd: Change in Collisions Between Park View St and Western Ave After Bus Lane Installation



Before bus lane vs after bus lane

Collision severity
Though collisions decreased after bus lane installation, they became more common in categories of moderate severity. Both “Complaint of Pain” and “Other Visible Injury” saw increases in proportion of collisions. Fatalities stayed the same, but considering that fewer collisions occurred after bus lane installation, that means it took fewer collisions to result in the same loss of life - another indicator that the severity of collisions increased after bus lane installation. All four fatalities in the “after” bus lane period were active transportation users – in contrast to the three active transportation users who lost their lives during the “before” period.

Table 9: Wilshire Blvd: Collision Severity Between Park View St and Western Ave Before-and-After Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	36% (253)	46% (326)	15% (107)	2% (15)	<1% (4)	100% (705)
After Bus Lane	29% (182)	48% (301)	19% (120)	2% (14)	<1% (4)	100% (621)
% Change	-7%	+2%	+4%	-	-	-

Shifting to a comparison of collisions during bus lane hours versus those during the same time of day before bus lane installation – the only difference in severity found during bus lane hours was a small increase in "other visible injury" collisions. There were no fatalities during bus lane operations. All four that occurred in the "after" period were during non-bus lane hours.

Table 10: Wilshire Blvd: Collision Severity Between Park View St and Western Ave (Peak Hours vs Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	24% (37)	56% (88)	17% (27)	2% (3)	<1% (1)	156
Bus Lane Hours	23% (31)	56% (75)	20% (27)	1% (2)	0% (0)	135
% change	-1%	-	+3%	-1%	-1%	-12%

Parties Involved

After bus lane installation, vehicle-pedestrian collision rates increased, while collision rates involving only vehicles decreased at a similar rate. Rates among all other actors stayed largely the same.

Table 11: Wilshire Blvd: Parties Involved in Collisions Between Park View St and Western Ave Before-and-After Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Before Bus Lane	12% (81)	7% (48)	71% (500)	5% (35)	5% (33)	<1% (8)	705
After Bus Lane	15% (91)	7% (45)	68% (421)	6% (37)	4% (24)	<1% (1)	621*
% change	+3%	-	-3%	+1%	-1%	-	-12%

*two collisions are not included in the row for "After Bus Lane". They are one collision that occurred with a car on the opposite roadway and one collision whose details were not stated.

Focusing on the period of interest, when the bus lane was operating – mixed outcomes occurred for bicyclists and pedestrians. Pedestrian-involved collisions became less common when the bus lane was in operation. On the other hand, bicyclist-involved collisions increased when the bus lane was in operation. Collisions with other vehicles decreased during bus lane hours. Other collisions that presumably did not involve another person increased (i.e., with a parked car or a fixed object).

Table 12: Wilshire Blvd: Parties Involved in Collisions Between Park View St and Western Ave (Peak Hour vs Bus Lane Hours)

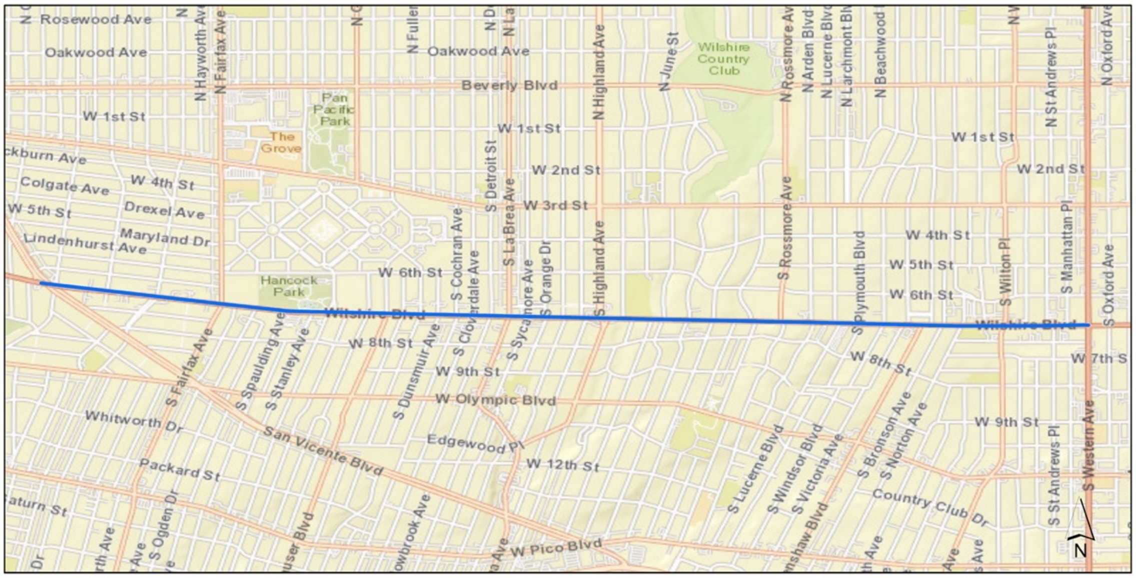
	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Peak Hours	17% (27)	5% (8)	76% (119)	0% (0)	1% (2)	0% (0)	156
Bus Lane Hours	12% (16)	13% (17)	70% (94)	1% (2)	4% (6)	0% (0)	135
% change	-5%	+8%	-6%	+1%	+3%	-	-13%

Summary
Collisions decreased at a higher rate during bus lane hours but were more injurious towards bicyclists and slightly more severe. Pedestrians, on the other hand, fared better during bus lane hours. Overall, collisions during bus lane hours involving people decreased (pedestrians and drivers) while collisions that did not involve people increased (with a parked car and fixed object).

Western Avenue to San Vicente Boulevard

Western Avenue to San Vicente Boulevard is part of a group of four segments on Wilshire Boulevard that were all simultaneously completed on April 8, 2015. The bus lane runs bi-directionally during morning and evening peak hours. It is the longest segment of any of the Wilshire Boulevard bus lanes, running 3.6 miles.

Figure 5: Wilshire Blvd: Western Ave to San Vicente Blvd Study Segment



0 0.5 1 Miles

Scale: 1:30,000

Legend

Wilshire: Western to San Vicente Peak-hour Bus Lane

Before Bus Lane Installation (May 2010 -Jan. 2015)

Table 13: Wilshire Blvd: Collisions Between Western Ave and San Vicente Blvd Before Bus Lane Installation

	Peak hours	Non-peak hour	Total Collisions
Before Bus Lane Installation	149	392	541

Peak hours vs non-peak hours

Collision Severity

Peak hours saw a slight decrease in severe collisions. The two fatalities in this study period were pedestrians. Of the collisions resulting in severe injury, three involved active transportation users during peak hours and 11 involved active transportation users during non-peak hours (see Table 64 in Appendix A).

Parties Involved
All parties except drivers fared better during peak hours (see Table 65 in Appendix A).

Summary
All parties during peak hours had lower rates of collisions with the exception of drivers. During peak hours, moderately severe collisions were more common. During non-peak hours, pedestrians and bicyclists were more at risk, particularly of fatal and severe-injury outcomes.

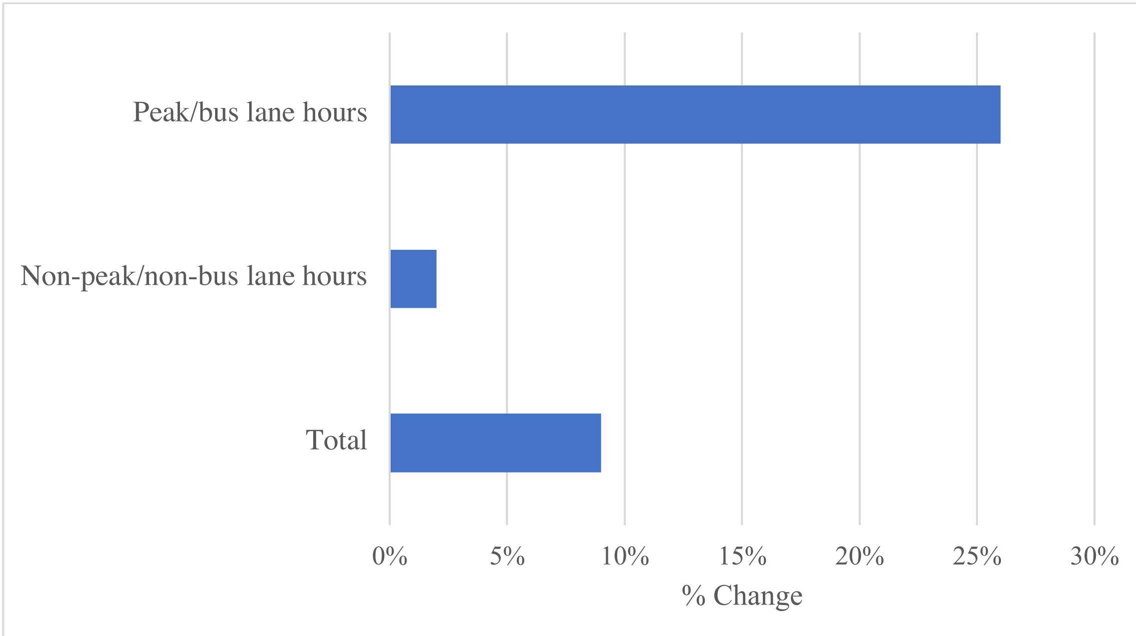
<u>After Bus Lane Installation (July 2015 - Mar. 2020)</u>

The Western-San Vicente bus lane paints a different picture than the Park View-Western bus lane segment, with substantial increases of collisions during its bus lane hours after installation.

Table 14: Wilshire Blvd: Collisions Between Western Ave and San Vicente Blvd Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	149	392	541
After Bus Lane Installation	188	400	588
% change	+26%	+2%	+9%

Figure 6: Wilshire Blvd: Change in Collisions Between Western Ave and San Vicente Blvd After Bus Lane Installation



Before bus lane vs after bus lane

Collision Severity
Collisions became slightly more severe after installation, with collisions resulting in injury going up. The proportion of severe and fatal collisions stayed the same. All four fatalities involved pedestrians – one occurred during bus lane operations, and three during non-bus lane hours.

Table 15: Wilshire Blvd: Collision Severity Between Western Ave and San Vicente Blvd Before-and-After Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	29% (158)	46% (251)	20% (110)	4% (20)	<1% (2)	541
After Bus Lane	24% (142)	46% (273)	25% (148)	4% (21)	<1% (4)	588
% change	-5%	-	+5%	-	-	+9%

When compared to peak hours collisions "before" the bus lane, collisions became more serious after the bus lane was installed, with one resulting in the fatality of a pedestrian.

The increase in overall “other visible injury” collisions observed after the bus lane installation occurred mostly during bus lane hours.

Table 16: Wilshire Blvd: Collision Severity Between Western Ave and San Vicente Blvd (Peak Hours vs Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	23% (35)	50% (74)	23% (35)	3% (5)	0% (0)	149
After Bus Lane	17% (32)	49% (92)	31% (58)	3% (5)	<1% (1)	188
% change	-6%	-1%	+8%	-	+<1%	+26%

Parties Involved
The increase in collisions that occurred in the “after” study period affected mostly drivers. Bicyclists and pedestrians experienced a decrease in collisions after bus lane installation.

Table 17: Wilshire Blvd: Parties Involved in Collisions Between Western Ave and San Vicente Blvd Before-and-After Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before Bus Lane	10% (51)	11% (59)	71% (383)	3% (17)	4% (24)	1% (7)	541
After Bus Lane	8% (49)	8% (49)	73% (427)	3% (20)	4% (26)	2% (10)	588*
% change	-2%	-3%	+2%	-	-	+1%	+9%

*After bus installation, four collisions involved a car on the opposite roadway and three were listed as non-collisions. Together they make up approximately 1% of collisions in this period.

During bus lane operations, the proportion of collisions between vehicles or between vehicles and pedestrians decreased slightly compared to the “before” period. The proportion of collisions involving bicyclists increased modestly.

Table 18: Wilshire Blvd: Parties Involved in Collisions Between Western Ave and San Vicente Blvd (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	7% (10)	10% (15)	79% (118)	1% (2)	3% (4)	0% (0)	149
Bus Lane Hours	6% (11)	12% (23)	78% (146)	1% (2)	2% (4)	0% (0)	188
% change	-1%	+2%	-1%	-	-1%	-	+26%

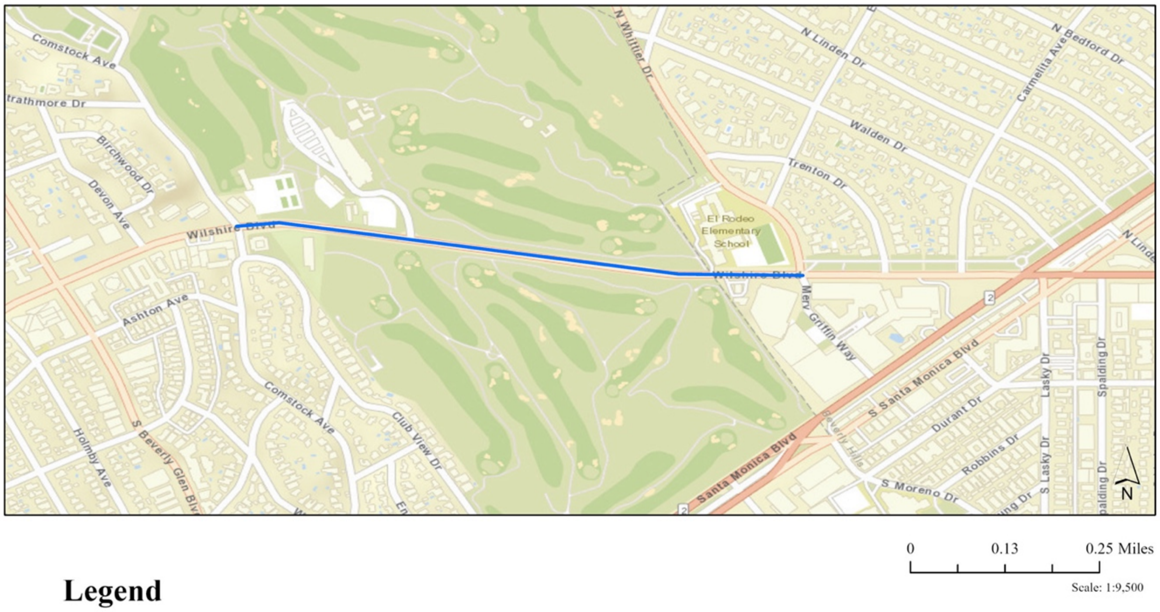
*During bus lane hours, one collision involved a car on the other side of the road, and another was listed as a "non-collision". Together they make up approximately 1% of collisions.

Summary
Collisions increased by 9% overall after bus lanes were installed, with large increases occurring during bus lane hours, specifically, those that were of "other visible injury". The corridor even saw an increase of one pedestrian fatality during bus lane hours. Bicyclists were disproportionately negatively impacted by the increase in collisions during bus lane hours.

Whittier Drive to Comstock Avenue

This is a short 0.6 mile-segment that runs between Beverly Hills and Westwood with one traffic-controlled t-intersection in between its endpoints. All but one collision occurred at the intersection of Wilshire Boulevard and Comstock Avenue in both the "before" and "after" study periods. The total collisions recorded on this segment were very small. Any difference may be insignificant due to the small sample of collisions. The segment was included for the purpose of offering a comprehensive review of the Wilshire Boulevard bus lanes.

Figure 7: Wilshire Blvd: Whittier Dr to Comstock Ave Study Segment



Legend

Wilshire: Whittier to Comstock Peak-hour Bus Lane

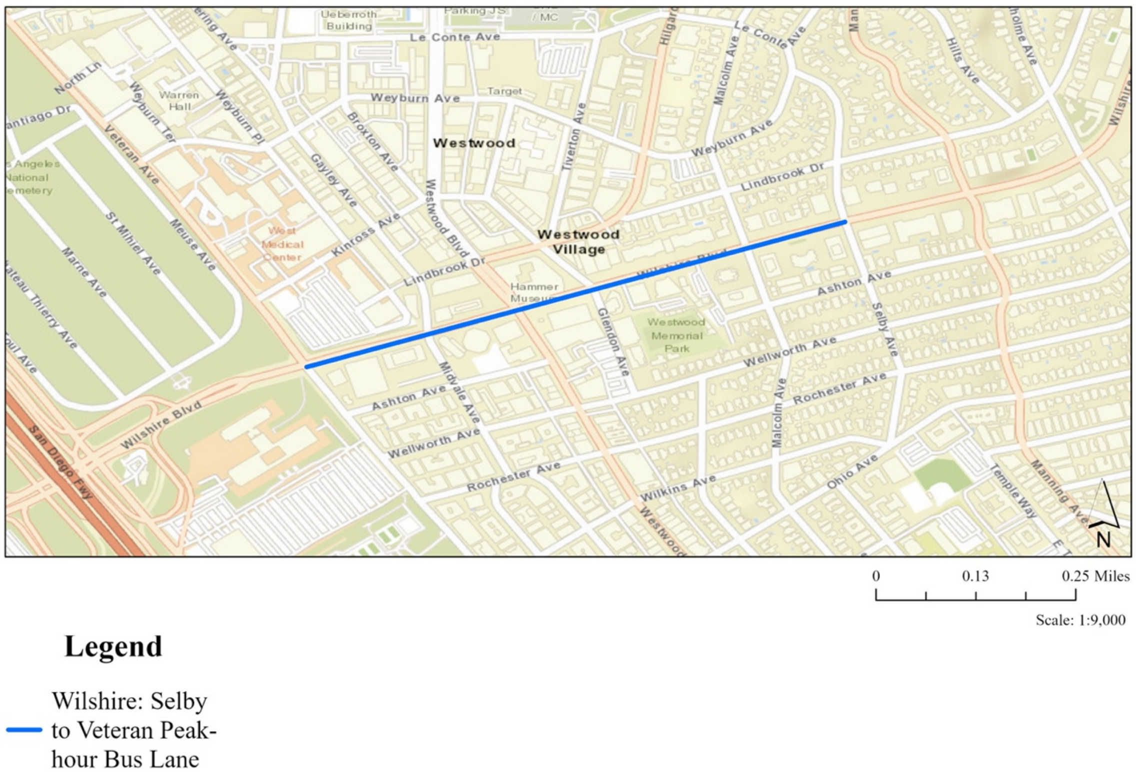
Table 19: Wilshire Blvd: Whittier Dr and Comstock Ave Data Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	11	19	30
After Bus Lane Installation	7	26	33
% change	-36%	+37%	+10%

Selby Avenue to Veteran Avenue

The segment is approximately 0.6 miles and runs along the southern border of Westwood Village. This is a very high density area because of the commercial and condominium high-rises that line the street. There is also high pedestrian activity due to the corridor's proximity to UCLA, where many students live and walk to school or to the local businesses in Westwood Village.

Figure 8: Wilshire Blvd: Selby Ave to Veteran Ave Study Segment



<u>Before Bus Lane Installation (May 2010 -Jan. 2015)</u>

Table 20: Wilshire Blvd: Selby Ave and Veteran Ave Collisions Before Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	36	109	145

Peak hours vs non-peak hours

Collision Severity
During the entire "before" study period, this segment of the Wilshire Blvd bus lane saw no severe injuries or fatalities (see Table 66 in Appendix A).

Parties Involved
A higher proportion of collisions during peak hours involved bicyclists and pedestrians (see Table 67 in Appendix A).

Summary
Collisions before bus lane installation were non-fatal or severe, but a higher proportion of them involved pedestrians and bicyclists during peak hours.

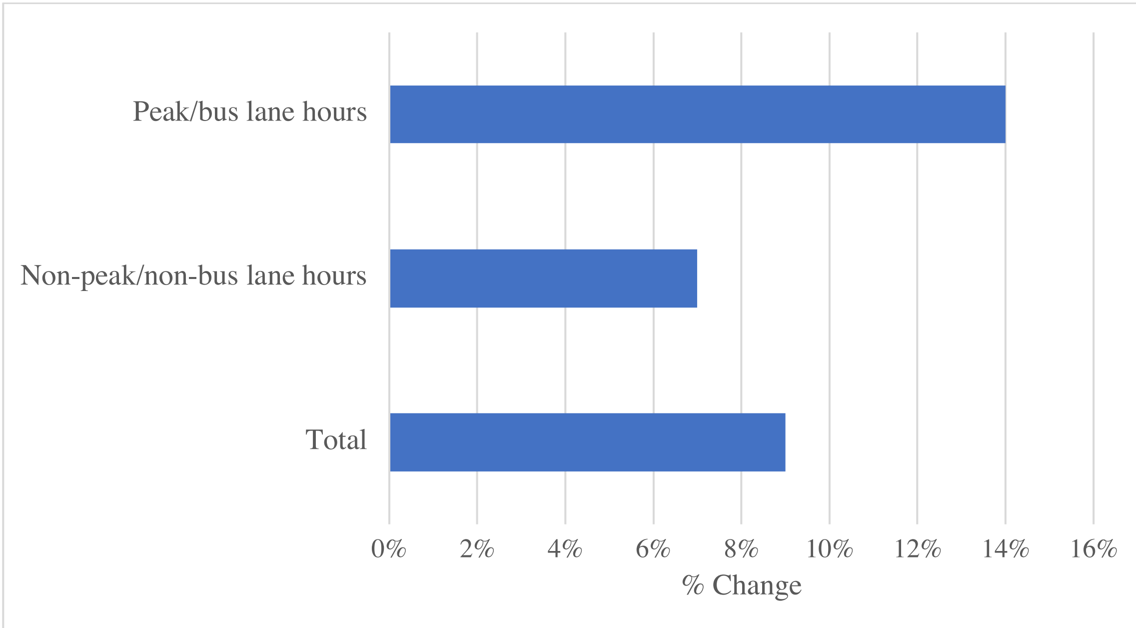
<u>After Bus Lane Installation (July 2015 - Mar. 2020)</u>

Collisions increased across the board on the corridor, but they increased at a larger rate during bus lane hours.

Table 21: Wilshire Blvd: Collisions Between Selby Ave to Veteran Ave Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	36	109	145
After Bus Lane Installation	41	117	158
% change	+14%	+7%	+9%

Figure 9: Wilshire Blvd: Change in Collisions Between Selby Ave and Veteran Ave After Bus Lane Installation



Before bus lane vs after bus lane

Collision Severity
Severe collisions increased from zero to one after bus lane installation – but the difference may be insignificant. Fatalities remained zero after the bus lane was installed.

Table 22: Wilshire Blvd: Collision Severity Between Selby Ave to Veteran Ave Before-and-After Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	31% (45)	51% (74)	18% (26)	0% (0)	0% (0)	145
After Bus Lane	25% (40)	55% (87)	19% (30)	1% (1)	0% (0)	158
% change	-6%	+4%	+1%	+1%	-	+9%

"Other visible injury" collisions increased, but severe and fatal collisions remained zero during bus lane hours. This means the one severe collision in the "after" study period occurred during non-bus lane hours.

Table 23: Wilshire Blvd: Collision Severity Between Selby Ave and Veteran Ave (Peak Hours vs. Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	25% (9)	64% (23)	11% (4)	0% (0)	0% (0)	36
Bus Lane Hours	15% (6)	66% (27)	20% (8)	0% (0)	0% (0)	41
% change	-10%	+2%	+9%	-	-	+14%

Parties Involved

In general, after bus lane installation, fewer collisions involved bicyclists, and the proportion of pedestrian-involved collisions stayed approximately the same. Most other categories stayed approximately constant with exceptions of collisions between vehicles which saw a 3% bump.

Table 24: Wilshire Blvd: Parties Involved in Collisions Between Selby Ave and Veteran Ave Before-and-After Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before Bus Lane	7% (10)	6% (9)	84% (122)	1% (1)	1% (1)	1% (1)	145*
After Bus Lane	7% (11)	3% (4)	87% (137)	0% (0)	1% (2)	1% (2)	158*
% change	-	-3%	+3%	-1%	-	-	+9%

*One collision was reported as a "non-collision" during both periods. They account for approximately 1% of collisions in both periods. One collision was reported as a collision with a vehicle from opposing traffic during the "after" study period. It accounts for approximately 1% of collisions.

When compared to its peak hour counterpart, bus lane hours saw increased safety for active transportation users, especially bicyclists. A larger proportion of the decrease in bicyclist-involved collisions on the corridor occurred when the bus lane was operating.

Table 25: Wilshire Blvd: Parties Involved in Collisions Between Selby Ave and Veteran Ave (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	8% (3)	8% (3)	83% (30)	0% (0)	0% (0)	0% (0)	36
Bus Lane Hours	7% (3)	2% (1)	90% (37)	0% (0)	0% (0)	0% (0)	41
% change	-1%	-6%	+7%	-	-	-	+14%

Summary
Collisions during bus lane hours increased at a larger rate than non-bus lane hours, but these collisions remained non-severe and non-fatal. Additionally, active transportation users saw a decrease in their proportion of collisions.

Bonsall Avenue to Federal Avenue

The segment is less than 0.5 miles long and runs approximately between the 405-freeway to Federal Avenue. The bus stop at Bonsall Avenue is on a road that is detached from the regular flow of traffic. Buses merge back into the traffic flow but maintain their own dedicated lane during peak hours. The total collisions on this segment were small and thus the changes in collisions from one period to the other may be insignificant. For example, peak hour collisions increased by 100% after installation, but this was as a result of only three additional collisions. The segment is included in the study only to share a comprehensive review of the Wilshire Boulevard bus lanes.

Figure 10: Wilshire Blvd: Bonsall Ave and Federal Ave Study Segment

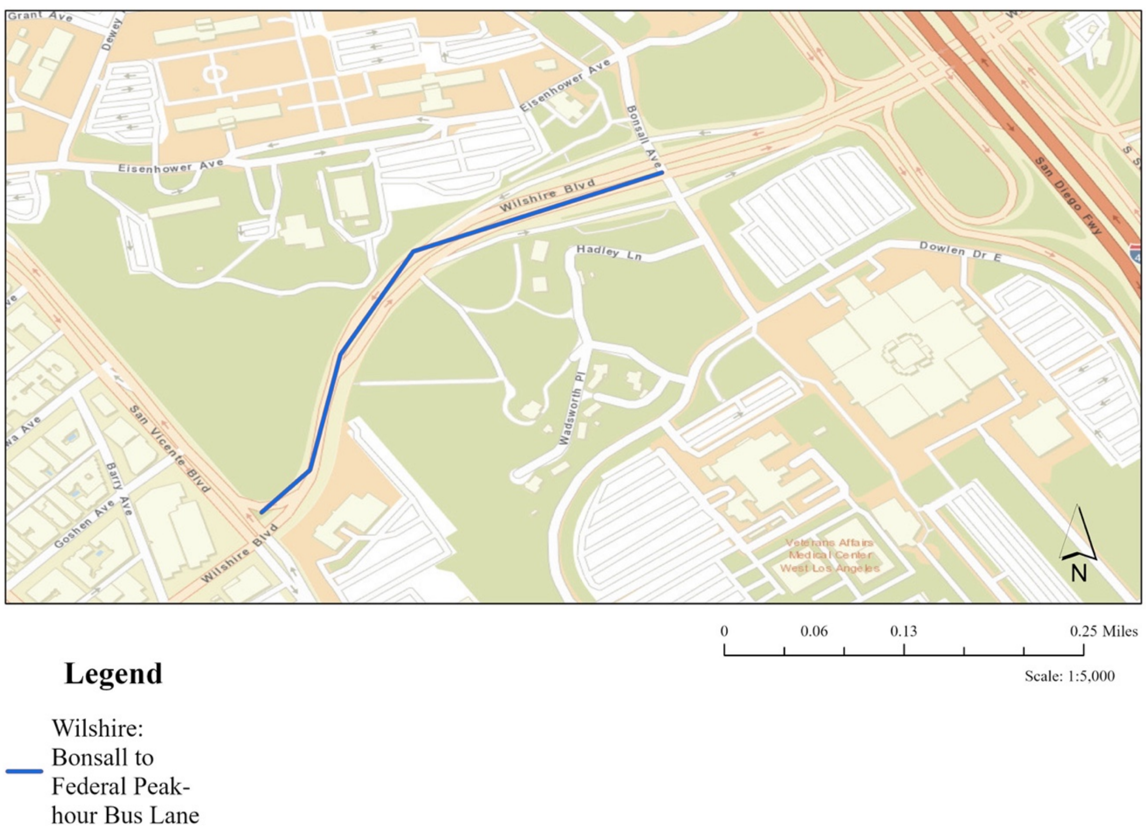


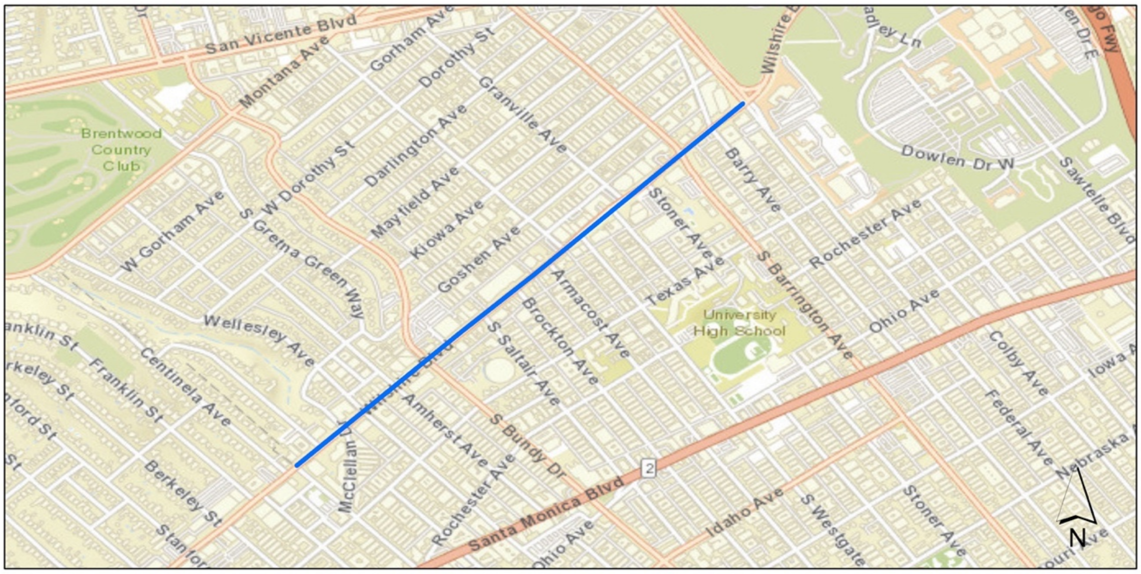
Table 26: Wilshire Blvd: Collisions Between Bonsall Ave and Federal Ave Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	3	18	21
After Bus Lane Installation	6	13	19
% change	+100%	-28%	+10%

Federal Avenue to Centinela Avenue

The final segment of the Wilshire Boulevard bus lane is 0.94 miles long and travels through a highly commercial corridor. Commercial activities include storefronts, strip malls, and midrise office buildings. Single-family homes and mid-density multifamily apartments surround the corridor.

Figure 11: Wilshire Blvd: Federal Ave to Centinela Ave Study Segment



0 0.13 0.25 Miles

Scale: 1:13,000

Legend

Wilshire: Federal to Centinela Peak-hour Bus Lane

Table 27: Wilshire Blvd: Collisions Between Federal Ave and Centinela Ave Before Bus Lane Installation

	Peak Hour Collisions	Non-peak hour collisions	Total Collisions
Before Bus Lane Installation	39	129	168

Peak hours vs non-peak hours

Collision Severity

Severe injuries occurred at approximately the same rates during peak and non-peak hours (the difference was precisely 0.23%), and there were zero fatalities on the corridor (see Table 68 in Appendix A).

Parties Involved
During peak hours, pedestrians experienced a higher rate and bicyclists experienced a lower rate of collisions (see Table 69 in Appendix A).

Summary
Collision severity was approximately the same throughout the day. Before bus installation, peak hours saw mixed outcomes for active transportation users with pedestrians experiencing a higher rate of collisions.

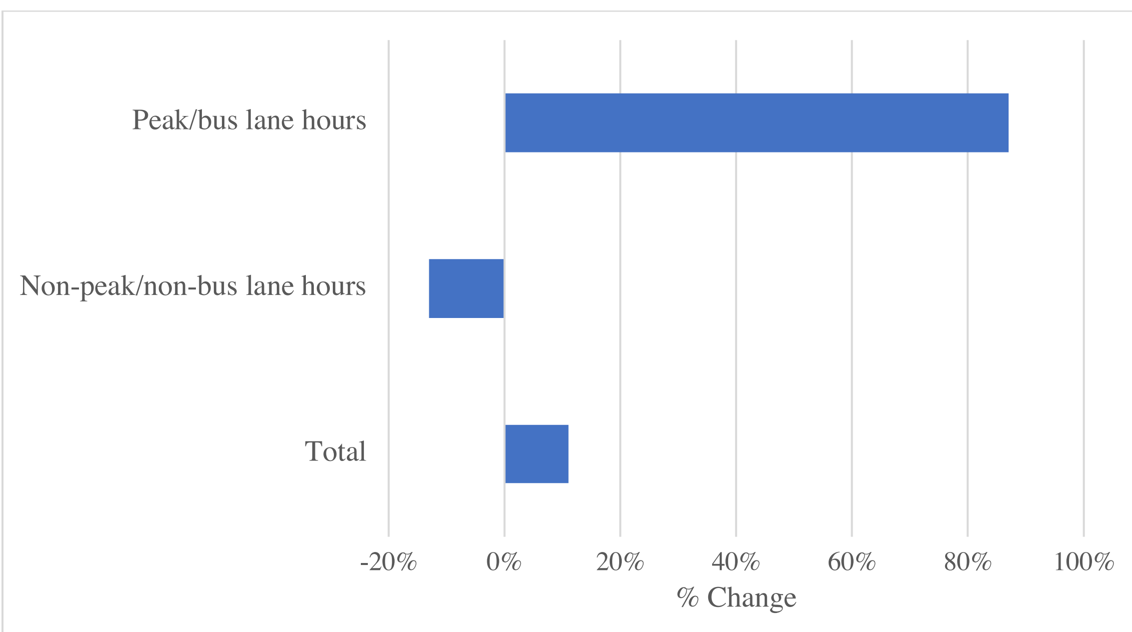
<u>After Bus Installation</u>

After bus lane installation, collisions almost doubled during bus lane hours. In contrast, collisions during non-bus lane hours decreased by 13%.

Table 28: Wilshire Blvd: Collisions Between Federal Ave and Centinela Ave Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	39	129	168
After Bus Lane Installation	73	113	186
% change	+87%	-13%	+11%

Figure 12: Wilshire Blvd: Change in Collisions Between Federal Ave and Centinela Ave After Bus Lane Installation



Before bus lane vs after bus lane

Collision Severity
Severe collisions slightly increased, and fatalities grew from zero to one.

Table 29: Wilshire Blvd: Collision Severity Between Federal Ave and Centinela Ave Before-and-After Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	23% (38)	49% (83)	26% (43)	2% (4)	0% (0)	168
After Bus Lane	16% (29)	56% (105)	24% (45)	3% (6)	1% (1)	186
% change	-7%	+7%	-2%	+1%	-1%	+11%

During bus lane hours, there was almost a two-fold increase in collisions. But within this increase, there was no change in the rate of severe or fatal collisions. Bus lane hours continued to see zero fatalities. That means the single fatality that occurred on the corridor happened during non-bus lane hours.

Table 30: Wilshire Blvd: Collision Severity Between Federal Ave and Centinela Ave (Peak Hours vs Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	15% (6)	56% (22)	26% (10)	3% (1)	0% (0)	39
Bus Lane Hours	15% (11)	53% (39)	29% (21)	3% (2)	0% (0)	73
% change	-	-3%	+3%	-	-	+87%

Parties Involved
After bus lane installation, bicyclists fared better but pedestrians fared slightly worse.

Table 31: Wilshire Blvd: Parties Involved in Collisions Between Federal Ave and Centinela Ave (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before Bus Lane	11% (19)	6% (10)	77% (130)	5% (8)	1% (1)	0% (0)	168
After Bus Lane	13% (24)	2% (4)	79% (147)	3% (5)	3% (5)	0% (0)	186*
% change	+2%	-4%	+2%	-2%	+2%	-	+11%

*One collision (approximately 1%) was listed as "not stated" after bus lane installation.

When compared to its peak hour counterpart, bus lane hours saw increased safety for active transportation users. This means that despite seeing a large increase in the number of collisions, bus lane hours saw a smaller proportion of them involving pedestrians and bicyclists. This also means that the overall rate of increase in pedestrian-involved collisions in the "after" study period occurred exclusively during non-bus lane hours.

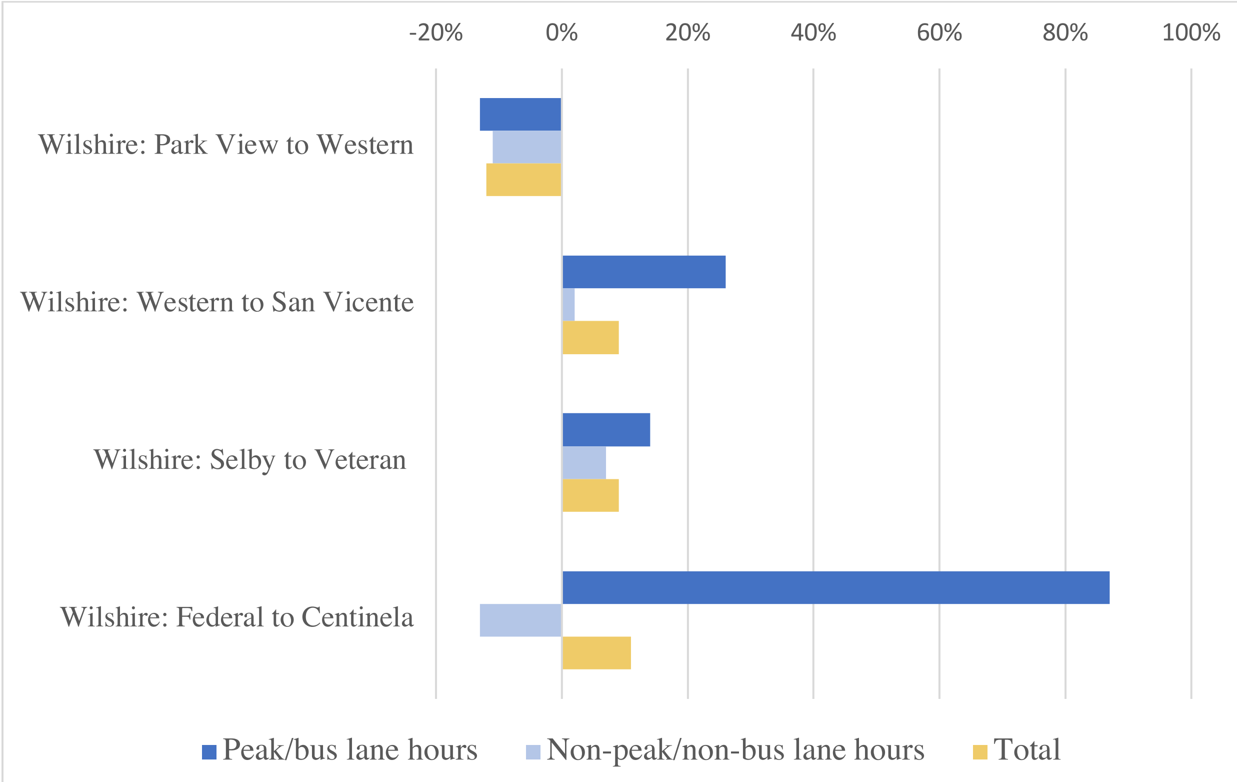
Table 32: Wilshire Blvd: Parties Involved in Collisions Between Federal Ave and Centinela Ave (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	15% (6)	3% (1)	79% (31)	0% (0)	3% (1)	0% (0)	39
Bus Lane Hours	12% (9)	1% (1)	84% (61)	0% (0)	3% (2)	0% (0)	73
% change	-3%	-2%	+5%	-	-	-	+87%

Summary

After bus lane installation, collisions substantially increased during bus lane hours, but the proportion of severe and fatal collisions stayed consistent. This differed from the slight uptick in the rate of severe and fatal injuries during non-bus lane hours. Active transportation users saw their proportion of collisions drop during bus lane hours. This differed from the increase in the rate of pedestrian-involved collisions during non-bus lane hours.

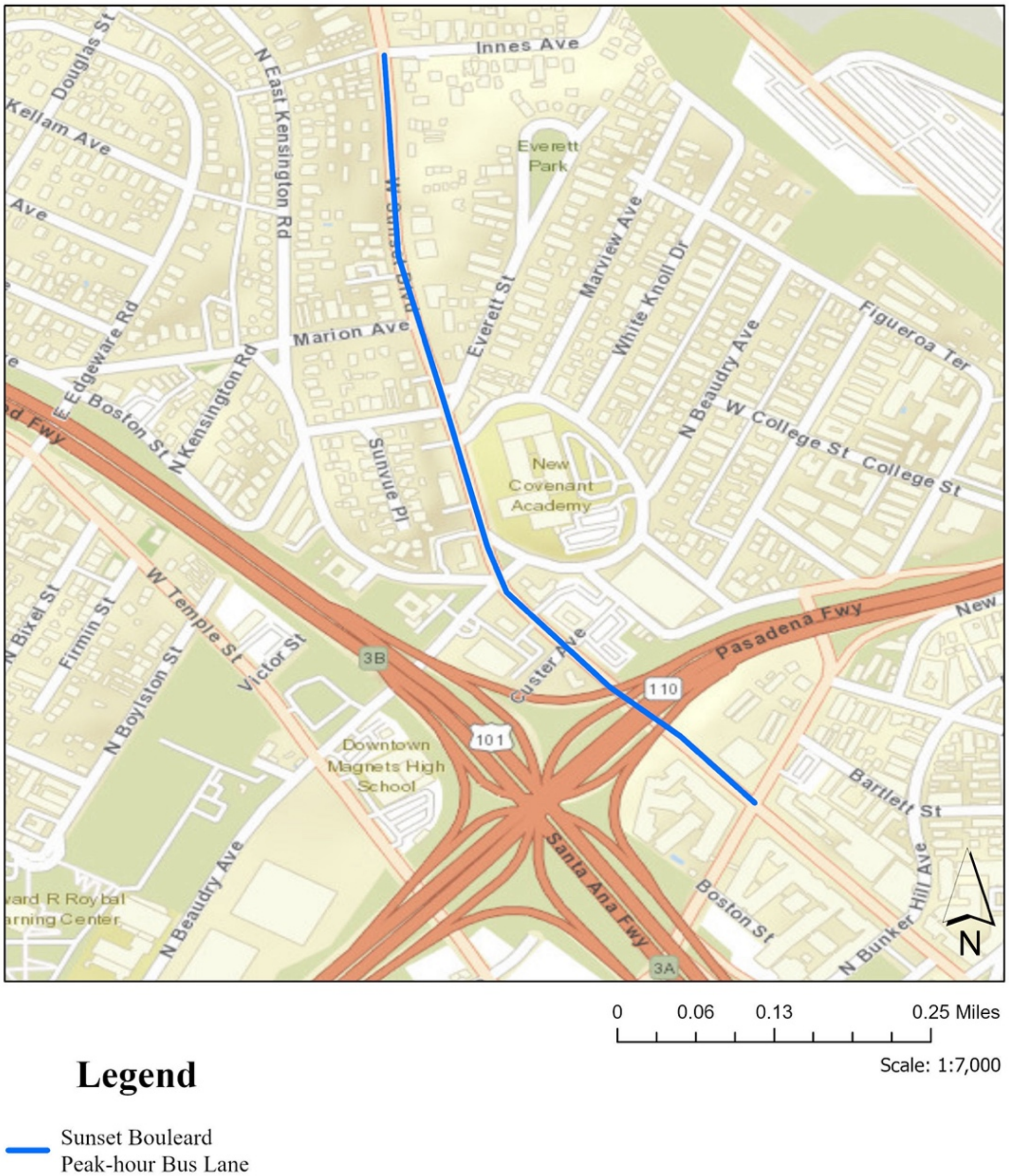
Figure 13: Change in Collisions on Wilshire Blvd After Bus Lane Installation



Model 2
Sunset Boulevard

The studied segment of the Sunset Boulevard bus lane extended from Figueroa Street to Innes Avenue and is 0.68 miles. Its design elements are similar to those of Wilshire Boulevard: the bus lane occupies the curbside lane, "Bus Only" is stenciled on the ground in white paint, and signage is installed indicating the lane is for buses and bikes only. This segment is unique compared to other bus lane segments because of its bus lane's unidirectional configuration. The bus lane operates exclusively EB in the morning peak period (7 am – 9 am) and exclusively WB in the evening peak period (4 pm – 7 pm) (see Methodology section for definition of EB and WB). The street is also unique because of the Dodger Stadium Express which has been in operation since 2010. The Dodger Stadium Express travels through the bus lane segment and has operated in its own separated bus lane since 2015. Since the Dodger Stadium Express is a bus lane with no consistent schedule, I distinguished collisions that had occurred during its hours of operation from the rest of the sample. Additionally, I leveraged the existence of the Express to get additional insight regarding street safety by measuring collisions per hour during Express operations. The hours the Dodger Stadium Express was in operation was estimated for both before-and-after study periods using the average length of a baseball game between 2005-2019 (Associated Press, 2019) and the number of home regular season and playoff games played. These hours were then used to measure a collisions per hour metric for the hours of Express operation during the two study periods. This metric is discussed below (after the discussion of findings for the segment's safety indicators).

Figure 14: Sunset Blvd Bus Lane Study Segment



Before Bus Lane Installation (Dec 2006-Mar 2013)

In total, 135 collisions occurred on the bus lane segment before the bus lane was installed when the Dodger Stadium Express was not in operation.

Table 33: Sunset Blvd: Collisions Between Figueroa St and Innes Ave Before Bus Lane Installation

	Peak hours	Non-peak hour	Total Collisions
Before Bus Lane Installation	41	94	135

Peak hours vs non-peak hours

Collision Severity
The proportion of collisions that resulted in a severe injury was slightly higher in the peak hour period (see Table 70 in Appendix A).

Parties Involved
During the peak hours, pedestrians and motor vehicles saw a higher proportion of collisions, whereas bicyclists experience a lower proportion of collisions (see Table 71 in Appendix A).

Dodger Shuttle Express
Six collisions occurred in tandem with the Dodger Stadium Express. None were severe or fatal.

Summary
A higher rate of severe collisions occurred during peak hours. Pedestrians and drivers experienced a higher rate of collisions during peak hours, whereas bicyclists experienced a lower rate.

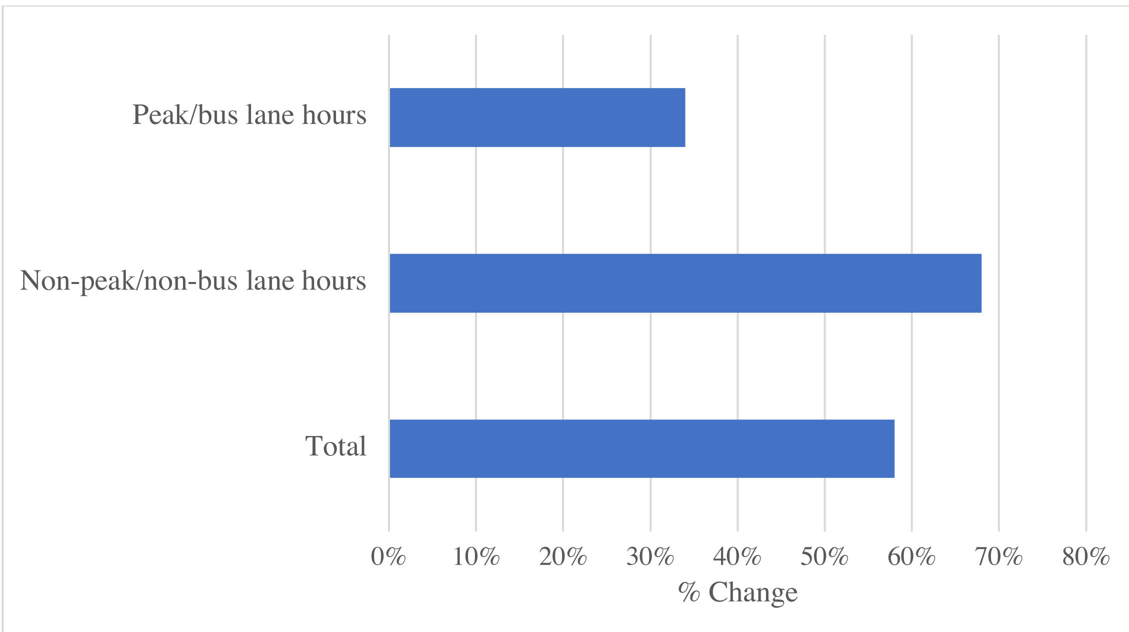
After Bus Installation (Dec. 2013-Mar. 2020)

Focusing solely on collisions that occurred outside of Express operations, 213 collisions occurred on the street segment after bus lane installation. I found that, though collisions had increased on the corridor, they increased at a much lower rate when the bus lane was in effect compared to when it was not.

Table 34: Sunset Blvd: Collisions Between Figueroa St and Innes Ave Before-and-After Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	41	94	135
After Bus Lane Installation	55	158	213
% change	+34%	+68%	+58%

Figure 15: Sunset Blvd: Change in Collisions Between Figueroa St and Innes Ave After Bus Lane Installation



Collision Severity
After bus lane installation, severe collisions decreased by 1%, but the difference may not be significant. Changes among collisions of lesser severity showed mixed outcomes, with increases or decreases of up to 3%.

Table 35: Sunset Blvd: Collision Severity Between Figueroa St and Innes Ave Before-and-After Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	33% (44)	42% (57)	21% (29)	4% (5)	0% (0)	135
After Bus Lane	35% (74)	39% (83)	23% (48)	3% (6)	0% (0)	213
% change	+2%	-3%	+2%	-1%	-	+58%

Focusing solely on a comparison of peak hours in the "before" study period and bus lane hours in the "after" study period – collisions did increase, but they appear to have become less severe.

Table 36: Sunset Blvd: Collision Severity Between Figueroa St and Innes Ave (Peak Hours vs. Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	32% (13)	46% (19)	17% (7)	5% (2)	0% (0)	41
Bus Lane Hours	35% (19)	47% (26)	16% (9)	2% (1)	0% (0)	55
% change	+3%	+1%	-1%	-3%	-	+34%

Parties Involved

After the bus lane was installed, pedestrian-involved collision rates increased slightly and bicyclist-involved collision decreased slightly.

Table 37: Sunset Blvd: Parties Involved in Collisions Between Figueroa St and Innes Ave Before-and-After Bus Lanes

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before Bus Lane	7% (9)	10% (13)	68% (92)	10% (14)	5% (7)	0% (0)	135
After Bus Lane	8% (16)	9% (20)	68% (144)	6% (13)	5% (11)	1% (3)	213*
Total	+1%	-1%	-	-4%	-	+1%	+58%

*Five collisions were with a car on the other side of the road and one was listed as "non-collision". Together, they made up approximately 3% of collisions after the bus lane

Compared to its pre-bus lane peak hour counterpart, pedestrians fared much better and bicyclists a worse during bus lane hours.

Table 38: Sunset Blvd: Parties Involved in Collisions Between Figueroa St and Innes Ave (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	12% (5)	5% (2)	73% (30)	2% (1)	7% (3)	0% (0)	41
Bus Lane Hours	4% (2)	9% (5)	76% (42)	2% (1)	7% (4)	0% (0)	55*
% change	-8%	+4%	+3%	-	-	-	+34%

*One collision occurred with a vehicle on the opposite side of the road, making up 2% of collisions during bus lane hours

Dodger Shuttle Express

During the "after" period, there were 23 collisions that occurred during Express operations – almost a four-times increase compared to Express collisions in the "before" study period. Still, the Express began operation in 2010 which means the "before" study period only captured three years of its operation. This is much less than the six years of operation in the "after" period captured. Furthermore, the Express operates when the Dodgers are playing, and the Dodgers were successful in reaching the playoffs more times in the "after" study period – extending their season and the number of hours the Express was operating. To ensure that collision increases did not happened because the Express ran more often, I normalized the number of collisions based on an estimate of hours of operation. I measured total hours of operation by considering the number of games played during the study period, the average length of a baseball game, the 90 minutes the shuttle runs before games, and the 45 minutes it runs after games. In the "before" study period, the six collisions during Express hours equated to one collision every 210 hours. In the "after" study period, the 23 collisions during Express hours equated to one collision every 143 hours. This affirms that though the Dodger Shuttle Express did operate more frequently in the "after" period, collisions also occurred at a more frequent hourly rate.

Summary

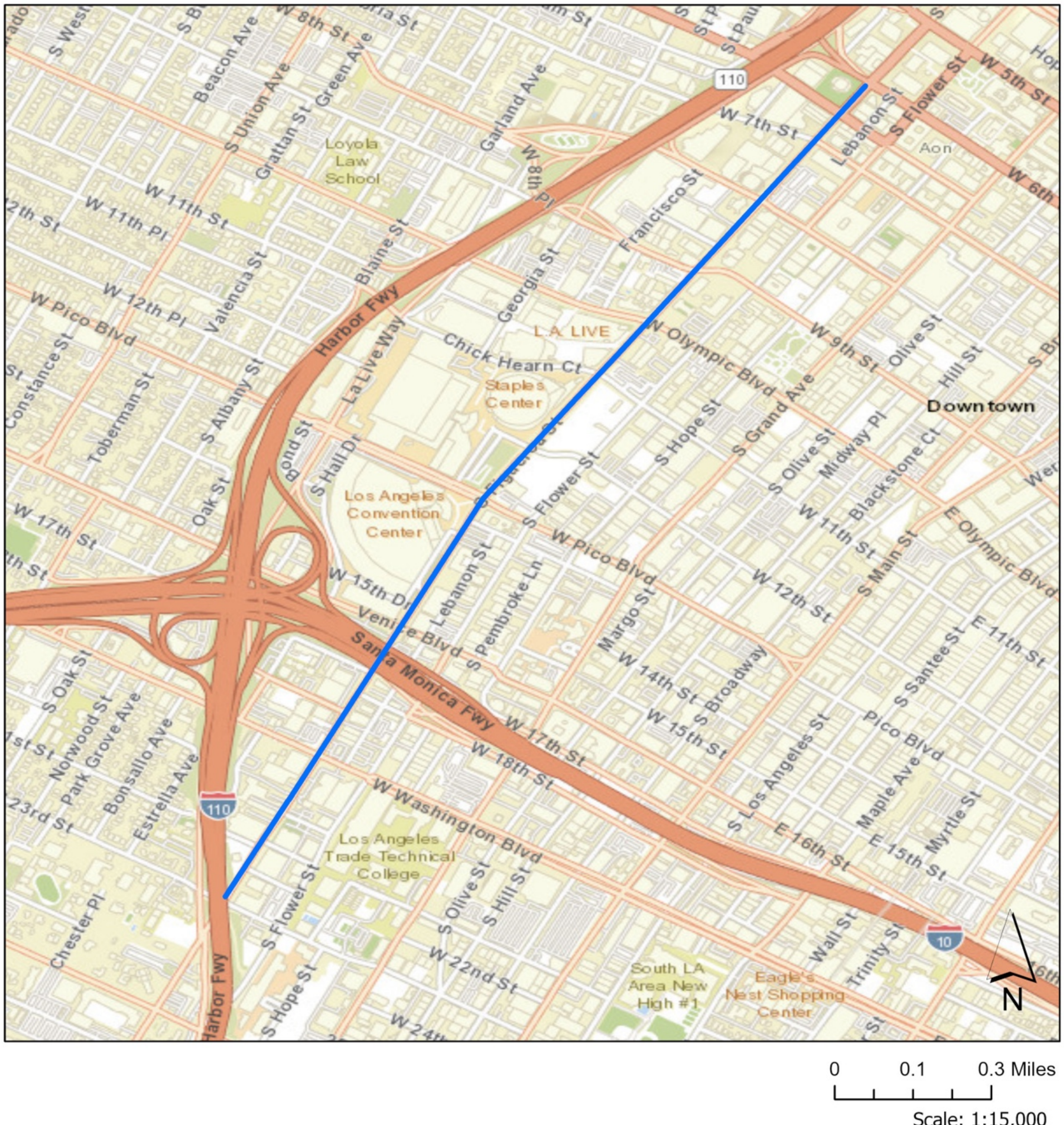
Collisions increased overall in the study period after the bus lane was installed, but they increased at a smaller rate during bus lane hours. Collisions overall in the "after" study period were less severe, due solely to decreases in collision severity during bus lane hours. Compared to its peak hour counterpart, pedestrians fared much better and bicyclists worse in the "after" study period during bus lane hours. This implies that the corridor is relatively safer when the bus lane is in operation, especially for pedestrians, but bus lane's design still cannot overcome the exogenous forces that are causing the uptick in overall collisions. For the Dodger Shuttle Express, a bi-directional bus that received a separated lane in the middle of the "after" period, collision rates also increased during its operations. This is another indicator that the Sunset Blvd bus lane cannot overcome the exogenous forces that are resulting in more traffic collisions.

Model 3

Figueroa Street: Peak Hour Bus Lane

The Figueroa Street bus lane extends from 23rd Street, near the 110 and 10 freeway interchange, to 6th Street in downtown. The bus lane mostly runs in the curbside lane and incorporates a "Bus Only" white painted stencil, a diamond shape white painted stencil, and signage indicating the lane is restricted to buses and bikes. Notably, the bus lane operates in the offset lane to accommodate other curb uses on specific blocks such as parking between 9th and 8th Street and a right turn lane at Olympic Boulevard. This 1.66-mile bus lane is unique in that traffic flows are different from the other studied segments. From 23rd Street to Olympic Boulevard, vehicles travel in both the northbound (NB) and southbound directions. From Olympic Boulevard to 6th Street, the traffic flow shifts to a one-way configuration as vehicles travel only northbound (NB). Because of this, the bus lane is unidirectional during the morning (7 am – 9 am) and evening (4 pm – 6 pm) peak periods, traveling only NB on the segment.

Figure 16: Figueroa St Peak Hour Bus Lane Study Segment



Legend

Figueroa Street Peak-hour Bus Lane

Before Bus Lane Installation (July 2008-July 2012)

Table 39: Figueroa St: Collisions Between 23rd St and 6th St Before Peak Hour Bus Lane Installation

	Peak hours	Non-peak hour	Total Collisions
Before Bus Lane Installation	55	250	305

Non-peak hours vs peak hours

Collision Severity
Peak hours did not see any severe collisions but did see one fatality which involved a pedestrian. In contrast, all six severe collisions that occurred on the corridor happened during non-peak hours, but this period did not have any fatalities (see Table 72 in Appendix A).

Parties Involved
Collisions during peak hours involved approximately 3% fewer bicyclists but the share of collisions involving pedestrians was the same during both periods. (see Table 73 in Appendix A).

Summary
Peak hour period collisions were generally less severe but did see one fatality. Parties involved in the collisions stayed mostly proportional during non-peak and peak hours, except for bicyclists who experienced safety gains during peak hours.

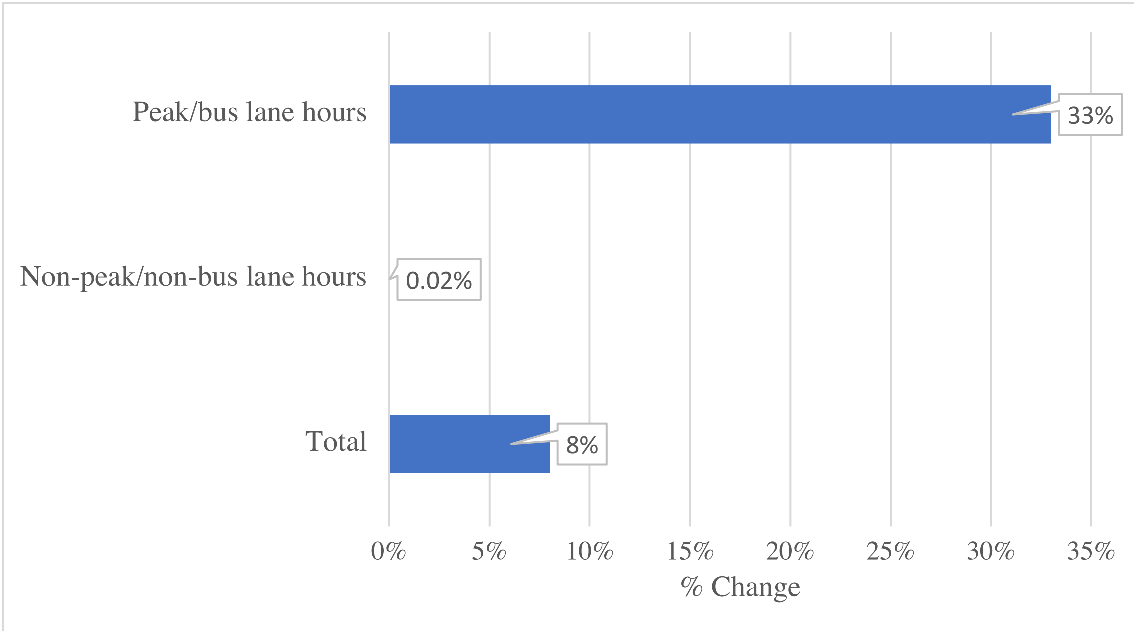
After Bus Installation (Jan. 2013-Jan. 2017)

Collisions increased in the "after" study period overall, but almost all of that increase occurred during bus lane hours.

Table 40: Figueroa St: Collisions Between 23rd St and 6th St Before-and-After Peak Hour Bus Lane Installation

	Peak/bus lane hours collisions	Non-peak/non-bus lane hours collisions	Total Collisions
Before Bus Lane Installation	55	250	305
After Bus Lane Installation	73	256	329
% change	+33%	+.02%	+8%

Figure 17: Figueroa St: Change in Collisions Between 23rd St and 6th St After Peak Hour Bus Lane Installation



Bus lane vs no bus lane

Collision Severity
I found indicators that collision severity decreased in the "after" study period. Severe injuries decreased from six to four total. No fatalities occurred during the "after" study period.

Table 41: Figueroa St: Collision Severity Between 23rd St and 6th St Before-and-After Peak Hour Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before Bus Lane	40% (123)	40% (123)	17% (52)	2% (6)	>1% (1)	305
After Bus Lane	38% (125)	40% (130)	21% (70)	1% (4)	0% (0)	329
% change	+2%	-	+4%	-1%	> -1%	+8%

When comparing bus lane hours to their pre-bus lane peak hour counterpart, there are also indicators that collisions became less serious. Bus lane hours saw a small decrease in collisions listed as "Other Visible Injury" and, more importantly, saw no fatalities.

Table 42: Figueroa St: Collision Severity Between 23rd St and 6th St (Peak Hours vs Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatalities	Total Collisions
Peak Hours	49% (27)	33% (18)	16% (9)	0% (0)	2% (1)	55
Bus Lane Hours	47% (34)	40% (29)	14% (10)	0% (0)	0% (0)	73
% change	-2%	+7%	-2%	-	-2%	+33%

Parties Involved

In the "after" study period, collisions involving either pedestrians or bicyclists increased. Bicyclist-involved collisions increased as much as 6%.

Table 43: Figueroa St: Parties Involved in Collisions Between 23rd St and 6th St Before-and-After Peak Hour Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before Bus Lane	7% (21)	7% (22)	78% (238)	3% (10)	4% (11)	1% (3)	305
After Bus Lane	8% (25)	13% (43)	71% (235)	4% (14)	3% (9)	1% (2)	329*
% change	+1%	+6%	-7%	+1%	-1%	-	+8%

*One collision was listed as "motor vehicle on other roadway". It made up less than 1% of collisions after bus lane installation.

When compared to their pre-bus lane peak hour counterpart, bicyclist-involved collisions decreased by 1% during bus lane hours. This indicates that the increase in bicyclist-involved collisions occurred exclusively during non-bus lane hours. Thus, though collisions did increase during bus lane hours, they became less dangerous for bicyclists.

Table 44: Figueroa St: Parties Involved in Collisions Between 23rd St and 6th St (Peak Hours vs Bus Lane Hours)

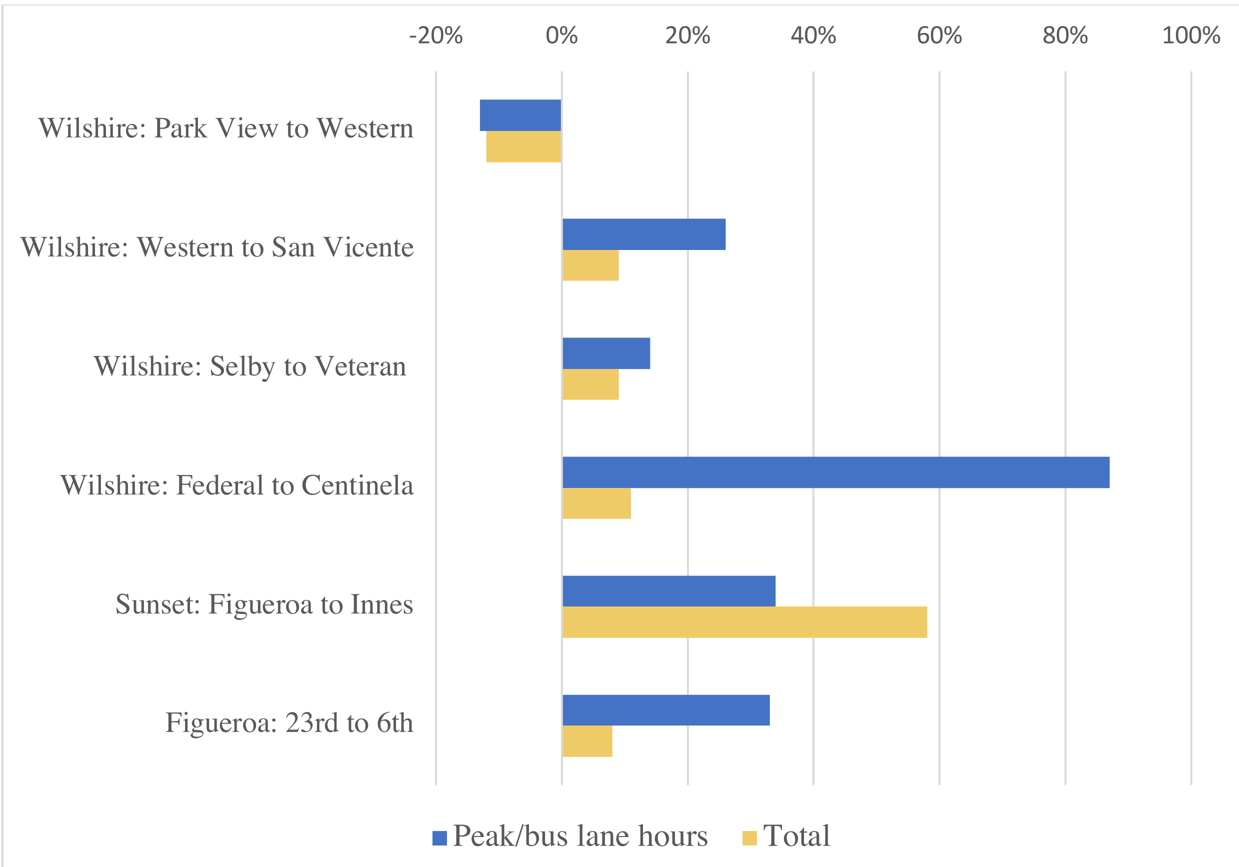
	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	7% (4)	5% (3)	82% (45)	4% (2)	2% (1)	0% (0)	55
Bus Lane Hours	7% (5)	4% (3)	75% (55)	10% (7)	1% (1)	1% (1)	73*
% Change	-	-1%	-7%	+6%	-1%	+1%	+33%

*One collision was listed as "motor vehicle on other roadway". It made up less than 1% of collisions after bus lane installation.

Summary

Overall, collisions increased after the bus lane installation and they almost exclusively occurred during bus lane hours. Still, even though collisions during non-bus lane hours saw essentially no change in their proportion, those that occurred became more severe and more dangerous to bicyclists. Alternatively, the large increases in collisions during bus lane hours were less severe and involved a lower proportion of bicyclists. When compared to their peak hour counterparts, collisions during bus lane hours became a little less severe and less fatal, but the difference may be statistically insignificant.

Figure 18: Changes in Collisions After Peak Hour Bus Lane Installation

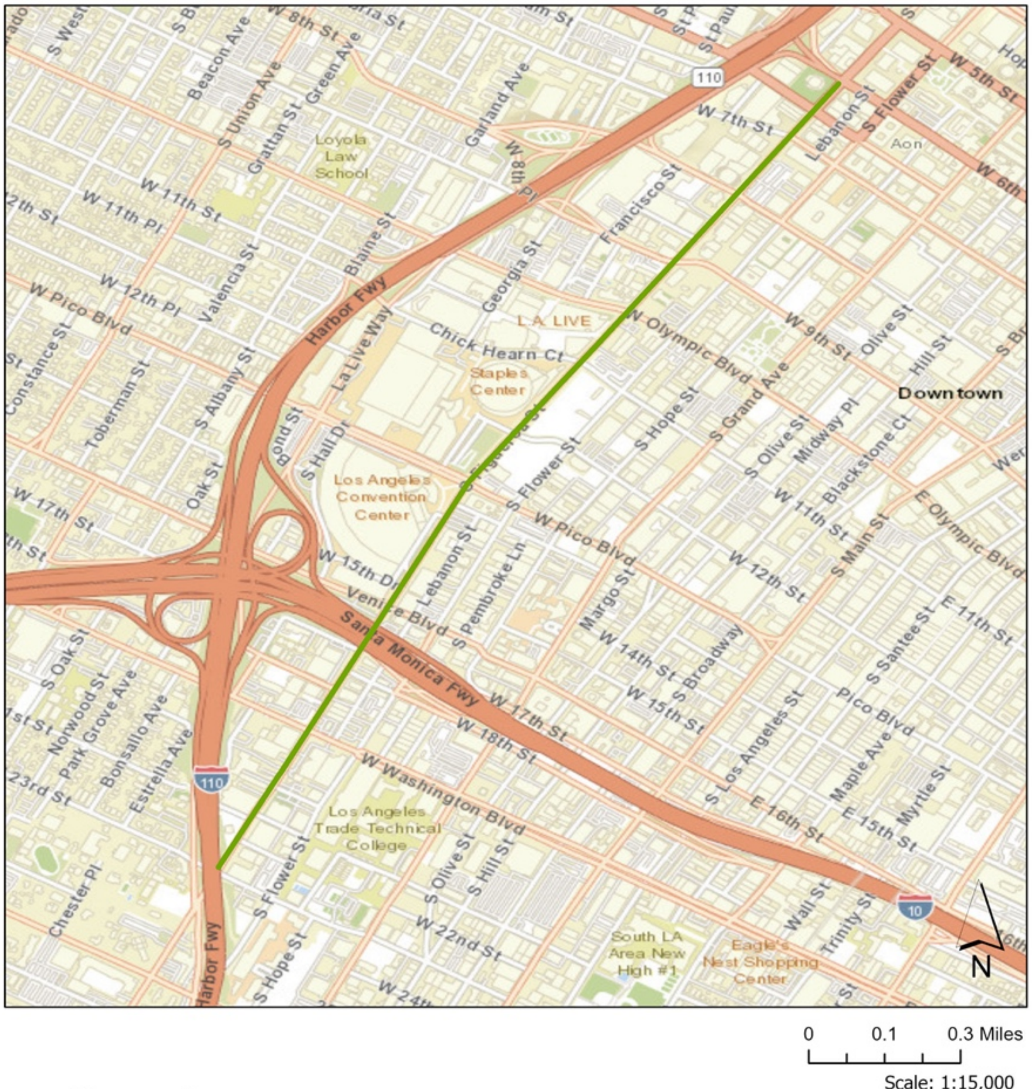


Model 4

Figueroa Street: All-day Bus Lane

In August 30, 2018, Figueroa Street went from having a peak hour bus lane to an all-day bus lane. The bus lane enhanced its existing design by installing bus bulbs (similar to bus boarders), bus islands (a waiting and boarding space for bus riders that is detached from the sidewalk), bus shelters, painted bike lanes, and separated bike lanes on specific blocks. Signage was updated to read “Buses Only”. This is a unique trajectory compared to the other studied segments. Because of its former peak hour configuration, I still separated collisions between Monday-Friday peak hours (7 am – 9 am, 4 pm – 6 pm) and non-peak hours, to analyze if the peak hours saw a difference in collisions once the bus lane went from running exclusively during peak hours to all day. The two study periods were limited to approximately 15 months each, due to the COVID-19 pandemic.

Figure 19: Figueroa St All-day Bus Lane Study Segment



Legend

Figueroa Street All-day Bus Lane

Before Bus Lane Installation (Feb. 28, 2017-May 30, 2018)

Table 45: Figueroa St: Collisions Between 23rd St and 6th St Before All-day Bus Lane Installation

	Peak hours	Non-peak hour	Total Collisions
Before All-day Bus Lane	28	79	107

Non-peak hours vs peak hours

Collision Severity

Due to the low number of peak hour collisions, it is difficult to make significant comparisons between the collision severity of those that occurred during the peak hours and non-peak hours. Still, in general, I find that collisions on the corridor were generally mild, with the majority resulting in no bodily harm. The one severe collision during non-peak hours involved a pedestrian whereas the one that occurred during peak hours was with another vehicle (see Table 74 in Appendix A).

Parties Involved

The low number of peak-hour collisions again makes it difficult to note significant differences among those involved in collisions when the peak hour bus lane was running and when it was not. Peak hours had a higher percentage of bicyclist-involved collisions and lower percentage of pedestrian-involved collisions, but it is difficult to say if this is meaningful (see Table 75 in Appendix A).

Summary

Collisions were mostly mild before Figueroa Street adopted an all-day bus lane. Motor vehicles made up 70% of the parties involved in collisions. Bicyclists made up approximately one-fifth of collisions during peak. bus lane hours, whereas pedestrians saw an increase in safety compared to non-peak hours. Deducing anything meaningful from collisions that happened during peak hour bus operations is difficult due to the small sample size.

After All-Day Bus Lane Installation (Nov. 30, 2018 – Mar. 1, 2020)

Collisions on the corridor overall increased after all-day bus installation. Though the bus lane being analyzed is an all-day bus lane, I still separated peak hour collisions to see how collisions changed during each period after the bus lane started operating all-day. I found a decrease in collisions during the peak hours but the rest of the day, and the corridor as a whole, did not see a decrease after the all-day bus lane went into effect.

Table 46: Figueroa St: Collisions Between 23rd St and 6th St Before-and-After All-day Bus Lane Installation

	Total Collisions	Non-peak hour	Peak hours
Before All-day Bus Lane	107	79	28
After All-day Bus lane	137	114	23
% Change	+28%	+44%	-18%

Figure 20: Figueroa St: Change in Collisions Between 23rd St and 6th St After All-day Bus Lane Installation

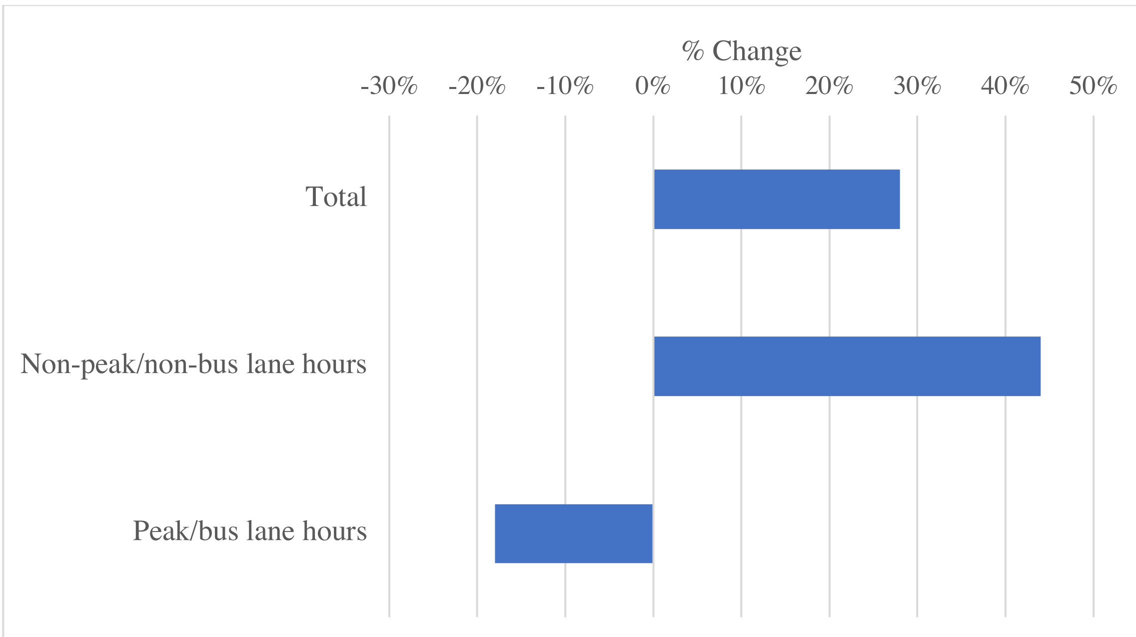
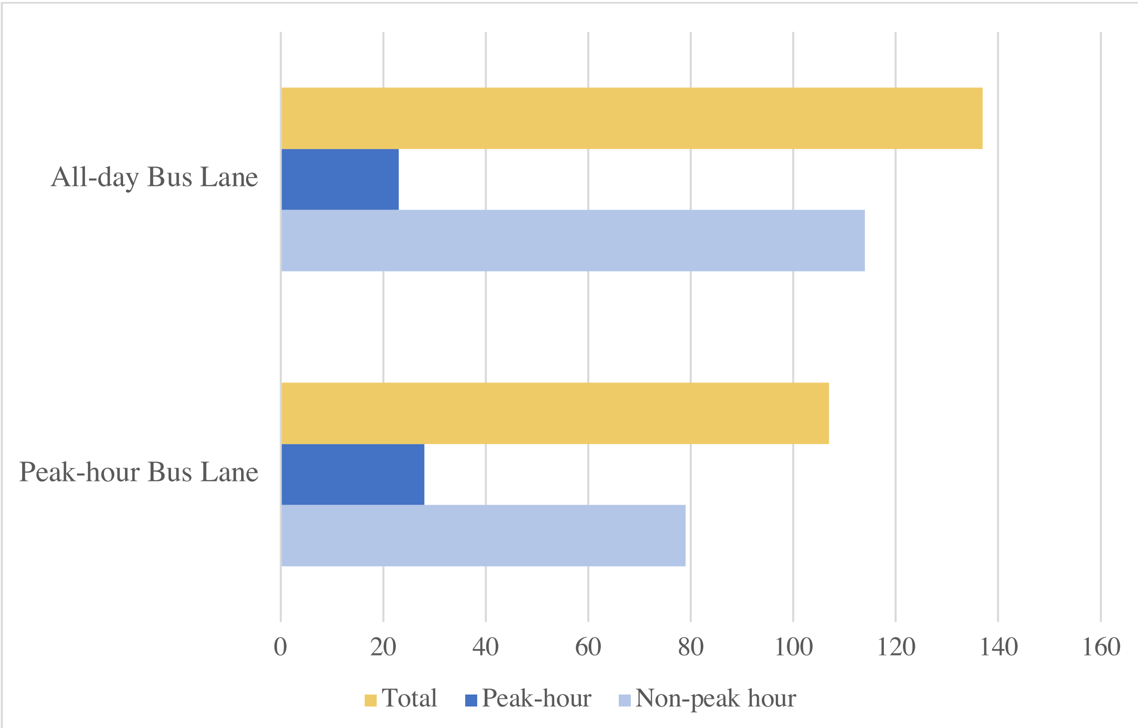


Figure 21: Figueroa St: Number of Collisions between 23rd St and 6th St (Peak Hour vs All-day Bus Lane Corridor)



Before all-day bus lane vs after all-day bus lane

Collision Severity
With the new all-day bus lane, severe and fatal collisions did not waver much. Decreases in "severe injury" and "other visible injury" collisions were dwarfed by large increases in "complaint of pain" collisions.

Table 47: Figueroa St: Collision Severity Between 23rd St and 6th St Before-and-After All-day Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Before All-day Bus Lane	47% (50)	28% (30)	24% (25)	2% (2)	0% (0)	107
After All-day Bus Lane	31% (43)	49% (67)	18% (25)	1% (2)	0% (0)	137
% change	-16%	+21%	-6%	-1%	-	+28%

Parties Involved
The proportion of collisions for each road user only changed slightly, with minor increases for pedestrians and minor decreases for bicyclists. The enhanced bicycle facilities may have caused the drop in the proportion of bicyclist-involved collisions.

Table 48: Figueroa St: Parties Involved in Collisions Between 23rd St and 6th St Before-and-After All-day Bus Lane

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Before All-day Bus Lane	7% (8)	11% (12)	69% (74)	6% (6)	4% (4)	1% (1)	107
After All-day Bus Lane	9% (12)	10% (14)	70% (96)	4% (5)	4% (5)	1% (1)	137*
% change	+2%	-1%	+1%	-2%	-	-	+28%

*For the All-day bus lane, two collisions were listed as "non-collisions", one collision was listed as "motor vehicle on other road" and one collision was listed as "not stated". Collectively, they made up approximately 4% of collisions.

Summary
Overall, the number of collisions increased after the all-day bus lane was installed. Minor changes in the proportion of collisions changed slightly, with increases for pedestrians and decreases for bicyclist. Severe collisions decreased slightly while fatal collision remained at zero. Figueroa Street was the only all-day bus lane with a sample of collisions large enough to study. Further analysis should be done for the all-day bus lanes recently installed in Downtown Los Angeles to measure if the relationships found are consistent or vary from Figueroa Street.

No Bus Lanes

Alvarado Street

Alvarado Street is analyzed to understand how collisions fared on corridors that did not have a bus lane during the study periods, but which have been identified as good candidates for a bus lane by LADOT and LA Metro. This implies that the street has similar characteristics to the other streets that were part of this study. Since the bus lanes in this study have different installation periods, and thus, different study periods, I paired Alvarado Street with the bus lane corridor that best matches its land use, speed limit, and number of lanes. Once paired, I adopted the bus lane corridor's study period to Alvarado Street. The bus lane corridor that best matches Alvarado Street is Sunset Boulevard.

Despite having one less lane, Alvarado Street matches Sunset's 35 miles-per-hour speed limit, mix of commercial and multifamily land uses, and proximity to a freeway. Alvarado Street also serves the same neighborhood of Echo Park. The bus lane on Alvarado Street is planned to run between 7th Street and Sunset Boulevard which, at a length of 1.6 miles, is longer than the 0.7 miles in length of the Sunset Boulevard segment between Figueroa Street and Innes Avenue. To have a segment that matches, I used a subset of the planned Alvarado bus lane from Beverly Boulevard to Sunset Boulevard. Using Sunset Boulevard's study periods of December 2006-March 2013 and December 2013 – March 2020, I pulled the collisions on Alvarado Street for these periods and analyzed them as I have done for the bus lane corridors. The question I sought to address was: how did collisions fare on corridors that are similar to the ones already studied but do not have a bus lane?

Figure 22: Alvarado St Study Segment

“Before” Study Period (December 2006 to March 2013)

Table 49: Alvarado St: Collisions Between Beverly Blvd and Sunset Blvd (December 2006 – March 2013)

	Peak hours	Non-peak hour	Total Collisions
Dec. ‘06 – Mar ‘13	81	320	401

Collision Severity
Collisions were more fatal during non-peak hours but more severe during peak hours. Approximately 80% of collisions resulted in either only property damage or “complaint of pain” (see Table 76 in Appendix A).

Parties Involved
During peak hours, bicyclists saw increased safety as opposed to pedestrians who saw a decrease in their safety (see Table 77 in Appendix A).

Summary
Peak hour collisions were non-fatal but were more severe for pedestrians. Bicyclists saw increased safety during peak hours.

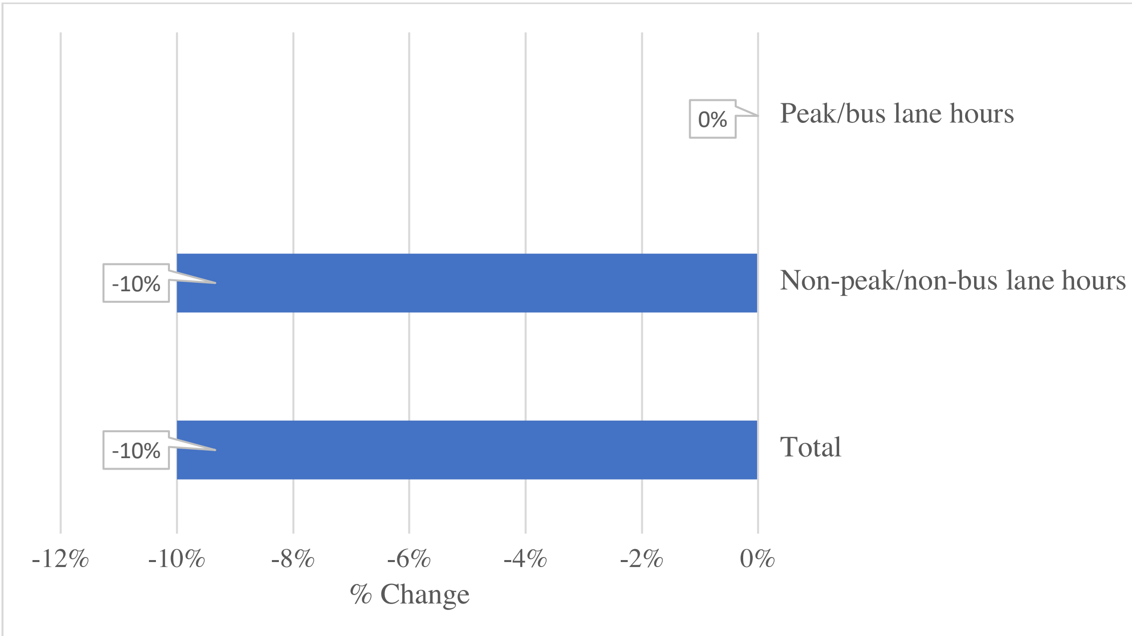
“After” Study Period (December 2013 – March 2020)

In the “after” study period, Alvarado Street saw an overall decrease in collisions and that decrease came exclusively during non-peak hours. Collisions during peak hours did not change at all. This is the complete opposite to the 34% overall increase in collisions that Sunset Boulevard experienced during the same period.

Table 50: Alvarado St: Collisions Between Beverly Blvd and Sunset Blvd (Dec. ’06 – Mar.’13 vs Dec. ’13-Mar. ’20)

	Peak hours	Non-peak hour	Total Collisions
Dec. ’06 – Mar.’13	81	320	401
Dec. ’13-Mar. ’20	81	290	371
% Change	-	-10%	-10%

Figure 23: Alvarado St: Change in Collisions Between Beverly Blvd and Sunset Blvd (Dec '06-Mar '13 vs Dec '13-Mar '20)



Collisions Severity
In the "after" study period, collisions became slightly less fatal and severe.

Table 51: Alvarado St: Collision Severity Between Beverly Blvd and Sunset Blvd (Dec. '06 – Mar.'13 vs Dec. '13-Mar. '20)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Dec. '06 – Mar.'13	40% (157)	39% (155)	20% (79)	2% (7)	1% (3)	401
Dec. '13-Mar. '20	29% (108)	50% (185)	19% (71)	1% (5)	<1% (2)	371
% Change	-11%	+11%	-1%	-1%	-	-10%

Comparing the two peak hour periods, collisions became less severe in the "after period". This is a similar trend to the one I found on Sunset Boulevard after the bus lane corridor was installed (see Table 30).

Table 52: Alvarado St: Collision Severity Between Beverly Blvd and Sunset Blvd During Peak Hour Periods (Dec. ’06 – Mar.’13 and Dec. ’13-Mar. ’20)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours ’06-‘13	36% (29)	46% (37)	14% (11)	5% (4)	0% (0)	81
Peak Hours ’13-‘20	25% (20)	60% (49)	14% (11)	1% (1)	0% (0)	81
% change	-11%	+14%	-	-4%	-	-

Table 36: Sunset Blvd: Collision Severity Between Figueroa St and Innes Ave (Peak Hours vs. Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	32% (13)	46% (19)	17% (7)	5% (2)	0% (0)	41
Bus Lane Hours	35% (19)	47% (26)	16% (9)	2% (1)	0% (0)	55
% change	+3%	+1%	-1%	-3%	-	+34%

Parties Involved
The proportion of bicyclists and pedestrians involved in collisions did not change on Alvarado Street between the two periods.

Table 53: Alvarado St: Parties Involved in Collisions Between Beverly Blvd and Sunset Blvd (Dec. ’06 – Mar.’13 and Dec. ’13-Mar. ’20)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Dec. ’06 – Mar.’13	7% (30)	4% (17)	80% (320)	5% (19)	4% (15)	0% (0)	401
Dec. ’13-Mar. ’20	7% (26)	4% (15)	81% (300)	4% (15)	2% (9)	<1% (1)	371*
% change	-	-	+1%	-1%	-2%	-	-10%

*Four collisions were listed as a motor vehicle on the other road, one collision was listed as “not stated”. Together they made up less than 2% of collisions in the “after” period.

Looking solely at peak hour periods, collisions in the “after” study period decreased for pedestrians on Alvarado Street, but stayed mostly the same for all other parties.

Table 54: Alvarado St: Parties Involved in Collisions Between Beverly Blvd and Sunset Blvd During Peak Hours (Dec. ’06 – Mar.’13 vs Dec. '13-Mar. ‘20)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours ’06-‘13	11% (9)	1% (1)	83% (67)	1% (1)	4% (3)	0% (0)	81
Peak Hours ’13-‘20	7% (6)	1% (1)	85% (69)	2% (2)	2% (2)	0% (0)	81*
% change	-4%	-	+2%	+1%	-2%	-	-

*One collision was listed as a motor vehicle on the other road, representing approximately 1% of collisions in the “after” period.

Pedestrian-involved collisions on Sunset Boulevard also decreased, but to a greater degree. On the other hand, bicyclists on Alvarado Street saw no change in collision rates, whereas Sunset Boulevard’s bus lane corridor saw an increase.

Table 38: Sunset Blvd: Parties Involved in Collisions Between Figueroa St and Innes Ave (Peak Hours vs Bus Lane Hours)

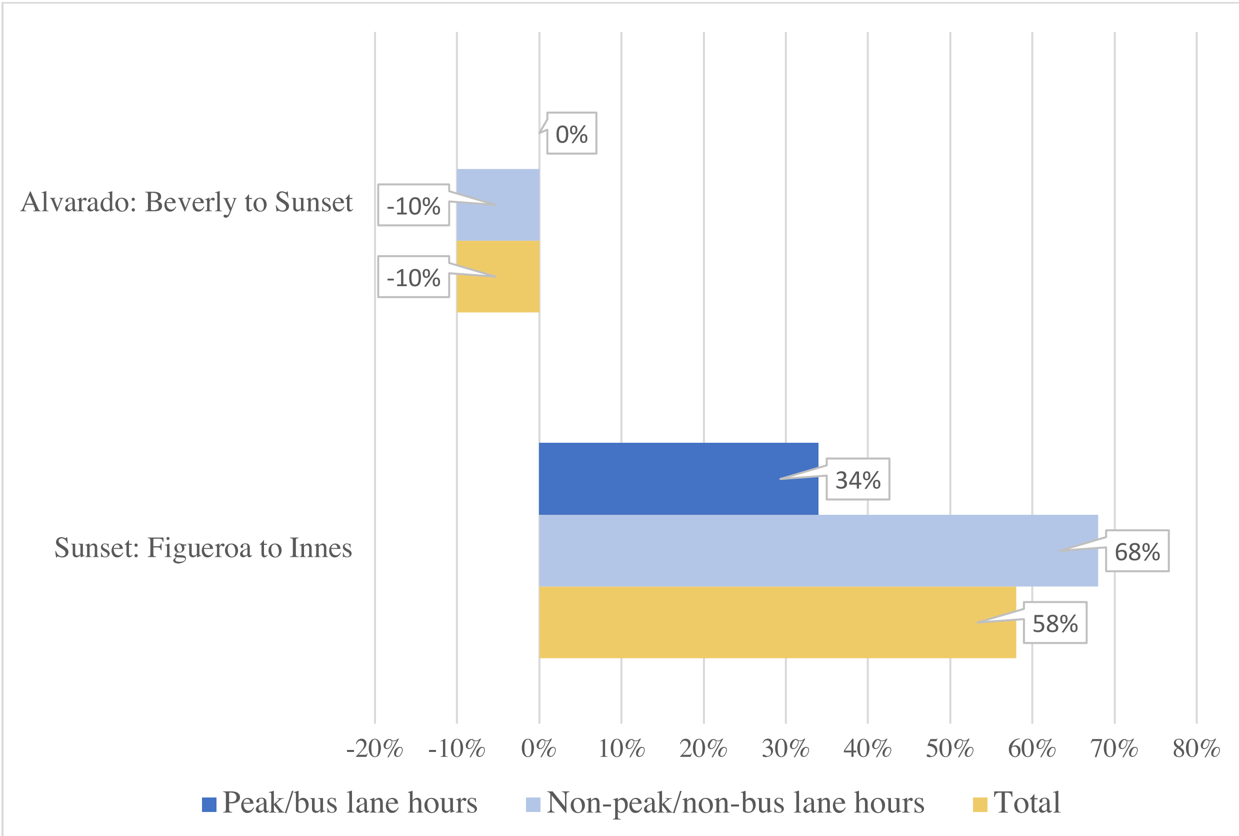
	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	12% (5)	5% (2)	73% (30)	2% (1)	7% (3)	0% (0)	41
Bus Lane Hours	4% (2)	9% (5)	76% (42)	2% (1)	7% (4)	0% (0)	55*
% change	-8%	+4%	+3%	-	-	-	+34%

*One collision was listed as a motor vehicle on the other road, representing approximately 1% of collisions in the “after” period.

Summary

On Alvarado Street, collisions overall decreased and peak hours saw no change. This is different than the overall and peak hour increases found on Sunset Boulevard during the same period. During peak hours, Alvarado Street and Sunset Boulevard collisions became less severe. Both corridors saw decreases in pedestrian-involved collisions, but the drop was greater for the Sunset Boulevard bus lane corridor. Alvarado Street’s peak hours were safer for bicyclists than Sunset Boulevard’s bus lane corridor.

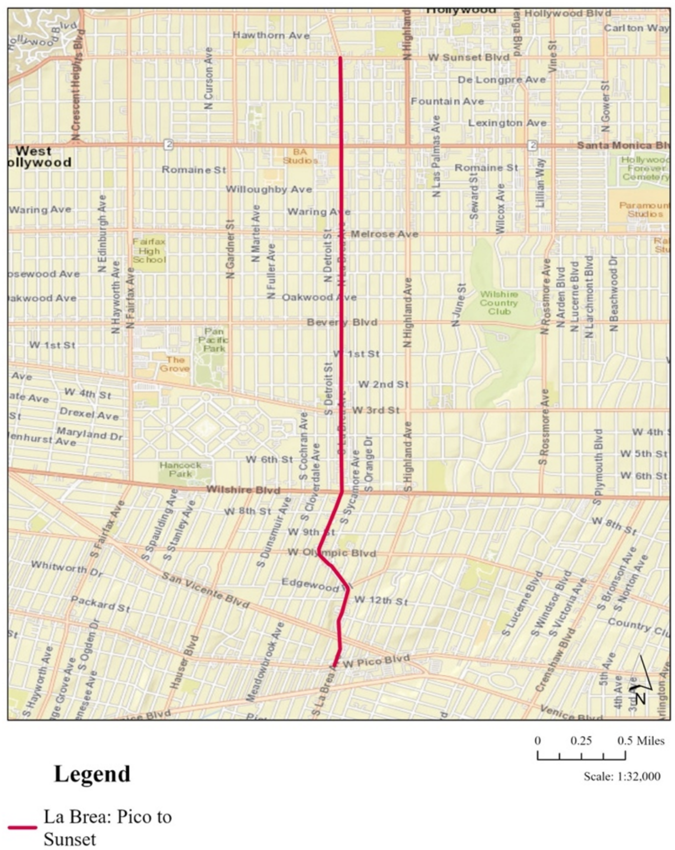
Figure 24: Collision Comparison of Alvarado St and Sunset Blvd (Dec '06-Mar '13 vs Dec '13-Mar '20)



La Brea Avenue

I analyzed La Brea Avenue to make another comparison of collisions on a corridor with no bus lane. La Brea is currently in the planning stages of having its bus lane installed. Much like I did with Alvarado Street, I paired La Brea Avenue with a bus laned street to establish temporal snapshots to analyze. In this case, I paired La Brea Avenue with Wilshire Boulevard between Western Avenue and San Vicente Boulevard. Both streets have almost entirely commercial land uses along their corridors, with brief stretches of single-family or industrial land uses. Tucked behind the front-facing land uses of the corridor are mostly multi-family homes. The speed limit on both streets is 35 miles per hour and both have seven travel lanes. The planned bus lane segment for La Brea Avenue is between Coliseum Street and Sunset Boulevard, which is longer than the 3.6 miles in length of the Wilshire Boulevard bus lane between Western and San Vicente. To have a segment that matches, I took a subset of the planned La Brea Avenue bus lane from Pico Boulevard to Sunset Boulevard. This specific segment was chosen because it is far from the freeway, which is a major land use that strays from the land uses common along Wilshire Boulevard. The chosen segment also intersects with the Western-San Vicente segment of the Wilshire Boulevard bus lane, meaning for at least an intersection, the environment is identical. I adopted the Western-San Vicente study periods of May 17, 2010 - Jan. 8, 2015 and July 8, 2015-Mar. 2020 in order to analyze collision changes along La Brea Avenue.

Figure 25: La Brea Ave Study Segment



<u>"Before" Study Period (May 2010 to January 2015)</u>

Table 55: La Brea Ave: Collisions Between Pico Blvd and Sunset Blvd (May 2010 – January 2015)

	Peak hours	Non-peak hour	Total Collisions
Before Bus Lane Installation	153	531	684

Collision Severity
Non-peak hours saw the only fatal and severe collisions on the corridor during this period (see Table 78 in Appendix A).

Parties Involved
Pedestrians saw slight decreases in collisions, and bicyclists saw slight increases in collisions during peak hours. The proportion of collisions with other motor vehicles increased during peak hours (see Table 79 in Appendix A).

Summary
Collisions were more fatal and severe during non-peak hours. During non-peak hours, pedestrians fared a little worst and bicyclists a little better.

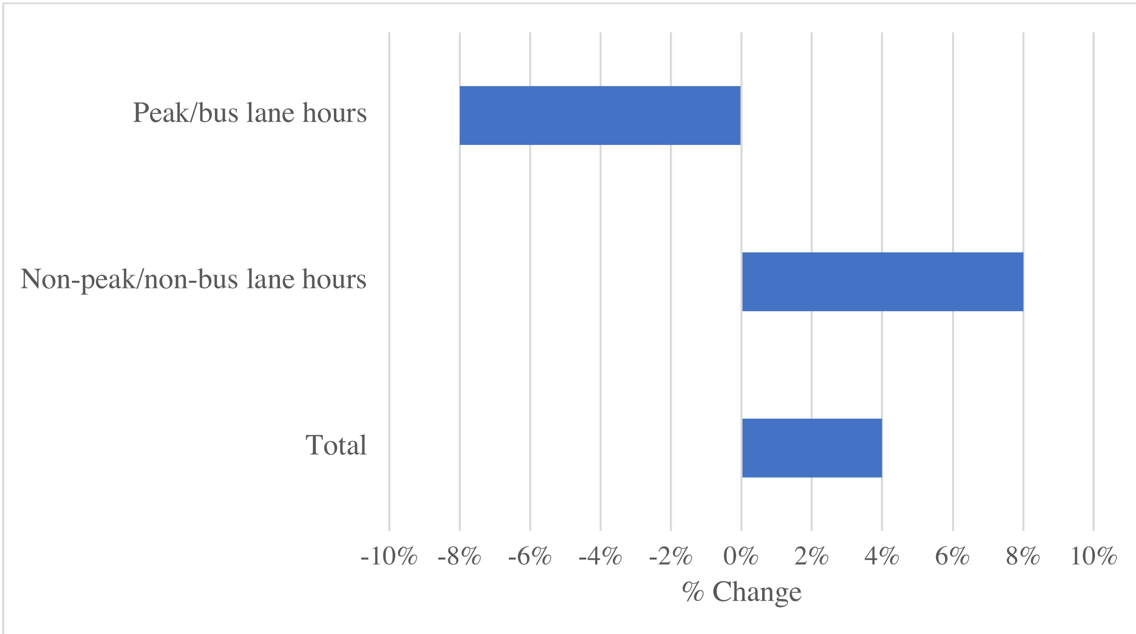
<u>"After" Study Period (July 8, 2015 to March 2020)</u>

Collisions overall increased on the corridor but decreased during peak hours.

Table 56: La Brea Ave: Collisions Between Pico Blvd and Sunset Blvd (May '10 – Jan.'15 vs July '15-Mar. '20)

	Peak hours	Non-peak hour	Total Collisions
May '10 – Jan.'15	153	531	684
July '15-Mar. '20	140	574	714
% Change	-8%	+8%	+4%

Figure 26: La Brea Ave: Change in Collisions Between Pico Blvd and Sunset Blvd (May '10-Jan '15 vs July '15-Mar '20)



Collisions Severity
In the "after" study period, collisions became more severe while fatalities stayed approximately consistent.

Table 57: La Brea Ave: Collision Severity Between Pico Blvd and Sunset Blvd (May '10 – Jan.'15 vs July '15-Mar. '20)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
May '10 – Jan.'15	29% (195)	50% (344)	18% (125)	2% (16)	<1% (4)	684
July '15-Mar. '20	31% (220)	43% (310)	21% (149)	4% (31)	<1% (4)	714
% Change	+2%	-7%	+3%	+2%	-	+4%

When comparing the peak hour periods of "before" and "after", severity increased.

Table 58: La Brea Ave: Collision Severity During Peak Hours Between Pico Blvd and Sunset Blvd (May ’10 – Jan.’15 vs July ’15-Mar. ’20)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours ’10-‘15	27% (41)	59% (91)	14% (21)	0% (0)	0% (0)	153
Peak Hours ’15-‘20	25% (35)	48% (67)	21% (30)	6% (8)	0% (0)	140
% change	-2%	-11%	+7%	+6%	-	-

When compared to its paired segment of the Wilshire Boulevard bus lane corridor, La Brea Avenue experienced a higher rate of severe collisions. On the other hand, La Brea Avenue saw no fatal collisions, whereas Wilshire Boulevard saw one.

Table 16: Wilshire Blvd: Collision Severity Between Western Ave and San Vicente Blvd (Peak Hours vs. Bus Lane Hours)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Peak Hours	23% (35)	50% (74)	23% (35)	3% (5)	0% (0)	149
Bus Lane Hours	17% (32)	49% (92)	31% (58)	3% (5)	<1% (1)	188
% change	-6%	-1%	+8%	-	+<1%	+26%

Parties Involved

Collisions increased for pedestrians and decreased slightly for bicyclists. Collisions with motor vehicles also saw a decrease.

Table 59: La Brea Ave: Parties Involved in Collisions Between Pico Blvd and Sunset Blvd (May ’10 – Jan.’15 vs July ’15-Mar. ’20)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
May ’10 - Jan. ‘15	6% (41)	6% (38)	80% (544)	5% (31)	4% (27)	<1% (3)	684
July ’15- Mar. ‘20	11% (79)	4% (25)	74% (528)	4% (31)	5% (37)	<1% (5)	714*
% Change	+5%	-2%	-6%	-1%	+1%	-	+4%

*Five collisions involved a car on the other side of the road. Three collisions were listed as “non-collision”. One collision was listed as “not stated”. Together they make up less than 2% of collisions.

Peak hour collisions among pedestrians and bicyclists increased in the "after" study period. This is particularly concerning considering severity also went up during the peak hour.

Table 60: La Brea Ave: Parties Involved in Collisions Between Pico Blvd and Sunset Blvd During Peak Hours (Dec. '06 – Mar.'13 vs Dec. '13-Mar. '20)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours '06-'13	7% (11)	4% (6)	86% (132)	2% (3)	0% (0)	<1% (1)	153
Peak Hours '13-'20	12% (17)	7% (10)	75% (105)	<1% (1)	4% (5)	1% (2)	140
% change	+5%	+3%	-11%	-1%	+4%	-	-8%

Compared to its paired Wilshire bus lane segment, pedestrians were much better off on the bus lane corridor. Bicyclists were also slightly better off on Wilshire Blvd compared to La Brea Ave, as well.

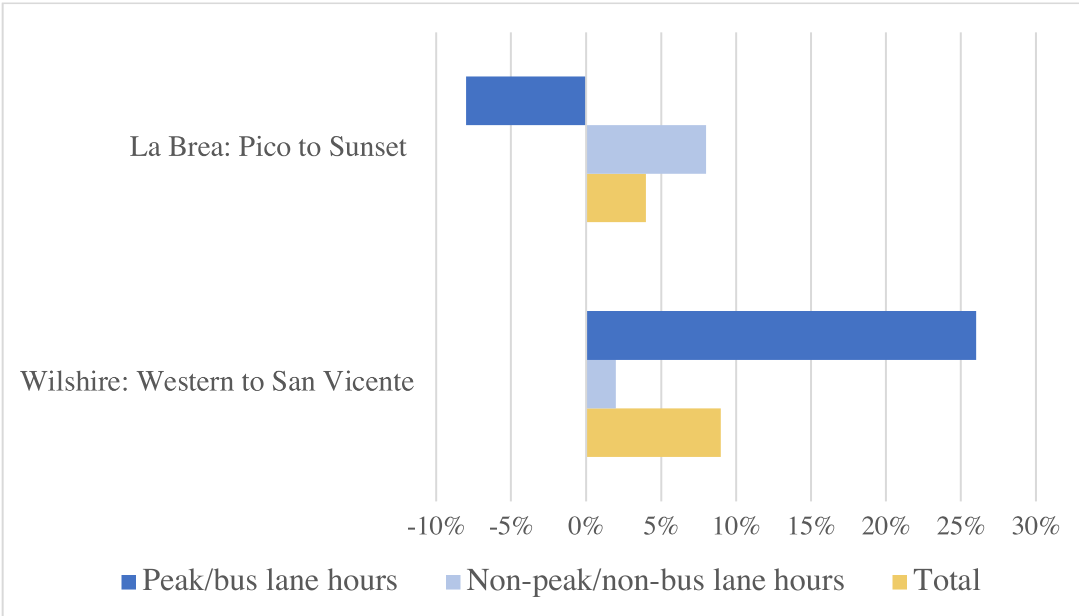
Table 18: Wilshire Blvd: Parties Involved in Collisions Between Western and San Vicente (Peak Hours vs Bus Lane Hours)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total Collisions
Peak Hours	7% (10)	10% (15)	79% (118)	1% (2)	3% (4)	0% (0)	149
Bus Lane Hours	6% (11)	12% (23)	78% (146)	1% (2)	2% (4)	0% (0)	188
% change	-1%	+2%	-1%	-	-1%	-	+26%

Summary

Though La Brea Avenue collisions decreased during peak hours, they became more severe and saw higher rate increases for pedestrians and bicyclists when compared to Wilshire's bus lane corridor. Whereas Wilshire saw one fatality during the bus lane study period, La Brea Avenue maintained zero fatalities. Even though one fatality may be statistically insignificant, it is still important to underscore this loss of life.

Figure 27: Collision Comparison of La Brea Ave and Wilshire Blvd (May '10-Jan '15 vs July '15-Mar '20)



Below is a summary table of the safety indicators for all the study streets. The size of the "yes" and "no" symbols indicate the magnitude of the outcome.

Table 61: Summary Table of Safety Outcomes on Studied Streets During Bus Lane Hours

	Collisions Reduced	Fatalities Reduced	Severe Injuries Reduced	Bicyclist-involved Reduced	Pedestrian-involved Reduced
PEAK HOUR					
Model 1					
Wilshire: Park View-Western	✓	✓	✓	⊘	✓
Wilshire: Western-San Vicente	⊘	✓	—	⊘	✓
Wilshire: Selby-Veteran	⊘	**0**	**0**	✓	✓
Wilshire: Federal-Centinela	⊘	**0**	—	✓	✓
Model 2					
Sunset Blvd	⊘	**0**	✓	⊘	✓
Model 3					
Figueroa St	⊘	✓	**0**	✓	—
No Bus Lane					
Alvarado St	—	**0**	✓	—	✓
La Brea Ave	✓	**0**	⊘	⊘	⊘
ALL DAY					
Model 4					
Figueroa St	⊘	**0**	✓	✓	⊘

Legend

✓ **Yes** ⊘ **No** — **No Change** **0: Zero Before and After**

Findings

Collisions increased during bus lane hours on all but one studied corridor but became less severe, less fatal, and involved a smaller proportion of pedestrians. This finding indicates that bus lanes may help reduce collision severity, fatalities, and pedestrian-involved collisions. The peak hour and all-day bus lanes in this report did not have design characteristics to make them distinguishable from one another. For all the peak hour lanes, a curbside lane was turned into a dedicated lane. Aside from signage indicating the lanes were for buses and bikes, and "Bus Only" painted in white on the lane, there was little to signal to drivers the lane was to be exclusively used by buses during certain hours. Figueroa's all-day bus lane looked very similar to its peak-hour predecessor. But along the entire corridor, bicycle facilities were enhanced and bus bulbs were installed, resulting in a decrease in bicyclist-involved and peak hour collisions. Still, the all-day bus lane experienced an increase in overall and pedestrian-involved collisions after installation. The adverse outcomes for pedestrians may be due to the high concentration of pedestrian activity between 7th and 8th Street where the city recorded the highest pedestrian count of 2019 (LADOT, 2021a). The streets with no bus lanes saw mixed safety outcomes. Alvarado Street experienced either constant or improved safety outcomes and La Brea Avenue experienced a decrease in peak hour collisions but an increase in severe injury, bicyclist, and pedestrian-involved collisions. The only bus lane segment that saw a decrease in collisions during bus lane hours was Wilshire Boulevard between Park View Street and Western Avenue. This is worth further analysis since all the studied bus lane segments were installed similarly. All operated in a curbside lane with stenciled white paint and incorporated signage. This implies that, though these design characteristics can play a role in reducing collision severity and fatalities, they are not sufficient to overcome other street design features that are influencing collision frequency and safety. What is it about the bus lane segment between Park View Street and Western Avenue that promotes safer streets? To answer this question, I conducted a site visit to this segment and to the Sunset Boulevard bus lane, the street with the second-highest increase in collisions during bus lane hours.

Qualitative Analysis

Upon seeing such large differences in changes of collision frequencies among streets with bus lanes, I conducted a site visit to the street with the largest decrease and the second-largest increase in collisions to assess the corridor's stress level, areas of conflict, bus lane obstruction, bus lane violations, speeds, and travel behavior. For the street with the largest decrease, I visited the Wilshire Boulevard bus lane, between Virgil Avenue and Western Avenue. For the street with the second-largest increase, I visited the Sunset Boulevard bus lane segment between Figueroa St and Innes Ave. Despite having a few high-stress intersections, I found Wilshire Boulevard to have traffic calming designs that made for a pleasant walk and relatively successful bus-only lane until 6 pm. On Sunset

Boulevard, I found the street blocks to be long with few access points, far fewer pedestrians, more bicyclists, and higher speeds. I conclude that the difference in collision frequency has to do with vehicle speeds, block length, and presence of controlled crosswalks; and the similarities in increased bicyclist-involved collisions has to do with a lack of bicycle infrastructure. Additionally, on both corridors, I found parked cars obstructing the bus lane near restaurants.

The street with the largest increase in collisions was Wilshire Boulevard between Federal Avenue and Centinela Avenue. I did not include this street in my qualitative analysis because in 2021 its bus lane received a new major design element: red paint (Linton, 2021a). Upon my visit to the corridor I immediately recorded drivers in the curbside lane observing the red paint and exiting the bus lane.

Painted red bus lane on Wilshire Blvd between Federal Ave and Centinela Ave during evening peak hour. Source: author’s photo, 2022

The purpose of the qualitative analysis is to better understand the differences in collision data between two studied streets. The collision data for this study ended at March 2020, before the red paint was installed. The red paint has likely altered the travel behavior, speeds, bus lane violations, and bus lane obstruction compared to those before March 2020. Thus, I look to the corridor with the second-largest increase – Sunset Boulevard – to inform my findings.

Wilshire Boulevard: Park View Street to Western Avenue

Wilshire Boulevard's street designs make for a pleasant and safe walk, but the lack of bicycle facilities and its drivers' inconsistent regard for the bus lane weakens the corridor's potential for enhanced safety on the corridor. The Wilshire Boulevard bus lane operates Monday-Friday, 7 am – 9 am and 4 pm – 7 pm. On Friday, March 4th, 2022, I visited the site between 5:15 pm – 6:45 pm.

From 5:15 pm - 6 pm, I observed a mostly well operating bus lane. Impressively enough, bus-only lane signs were posted in both directions at every intersection I crossed during my site visit. Cars entered the lane, but almost all would subsequently turn right at the next available intersection – a legal use of the lane. While standing at Wilshire/Normandie, a vehicle illegally used the bus lane to drive through the intersection every other green light. Though this is a clear violation, it did not once inhibit a bus from passing through. Before 6 pm, approximately five vehicles illegally blocked the corridor's bus lane for a length of time that could have obstructed a bus. That's roughly one car every nine minutes. After 6 pm, though, I saw drivers treat the bus lane completely differently. Between 6 pm – 6:45 pm, I saw 22 vehicles blocking the bus lane, some with no driver in the car. That is roughly one car every two minutes. About half of these vehicles were clustered between Normandie Ave and Kenmore Ave where there is a concentration of popular restaurants. Before 6 pm, I had only observed one parked car in this specific area.

Five cars parked on Wilshire Blvd between Normandie Ave and Mariposa Ave at 6:02 pm during bus lane hours. Source: author's photo, 2022

A mixed-use transit-oriented development project at Wilshire/Vermont also saw a cluster of five parked cars in its bus lane. I witnessed a bus maneuver around these vehicles on three separate occasions, and each time the merging bus caused a shock to the flow of traffic. Due to the weight and length of the bus, this maneuver took longer to complete than a normal-sized car would, abruptly bringing a growing queue of cars to a halt in the adjacent lane. My observation of these moments made for some of the highest-stressed interactions on the corridor. I observed traffic enforcement once, 16 minutes prior to the termination of bus lane operation.

Outside of these scenarios, I found the corridor very pleasant to walk. On almost every block, there were large planters that separated the curb from the walkway. This created a buffer that offered a sense of security to pedestrians.

Large planters enhance a sense of security for pedestrian by serving as a barrier from moving vehicles. Source: author's photo, 2022

Block-lengths were short, creating convenient access points to cross the street. I found the highest concentration of pedestrians at intersections where there were Metro D Line transit stops: Western Avenue, Normandie Avenue and Vermont Avenue. Incidentally, I also found these intersections to be the highest-stress intersections of my site visit. This aligns with research from Duduta, et al (2015) which found a higher number of collisions occur at major transfer stations due in part to the high concentration of pedestrian activity. Even though the bus lane allows bicyclists, I found most instead using the sidewalks (see Appendix B). Bicyclist-involved collisions were the only safety indicator metric that this bus lane segment failed at improving. With this in mind, I interpret this to mean that the bus lane is not perceived and experienced by bicyclists to be a sufficiently safe enough bicycle facility. The tree canopy was consistent and thick for the most densely developed part of the corridor, between Harvard Boulevard and Catalina Street. Much like the planters, these trees create a physical and psychological barrier for pedestrians using the sidewalk (MacDonald, 2007). While driving down Wilshire Boulevard, I found the trees psychologically inducing me to reduce my travel speed. Studies have shown that trees planted in certain settings help reduce speeds (Naderi, et al, 2008). Overall, the Wilshire Blvd bus lane between Park View-Western was pleasant for a pedestrian except at key intersections that overlapped with Metro D Line transit stops and after 6 pm when bus lane obstruction became prevalent. Addressing these challenges would enhance street safety on the corridor.

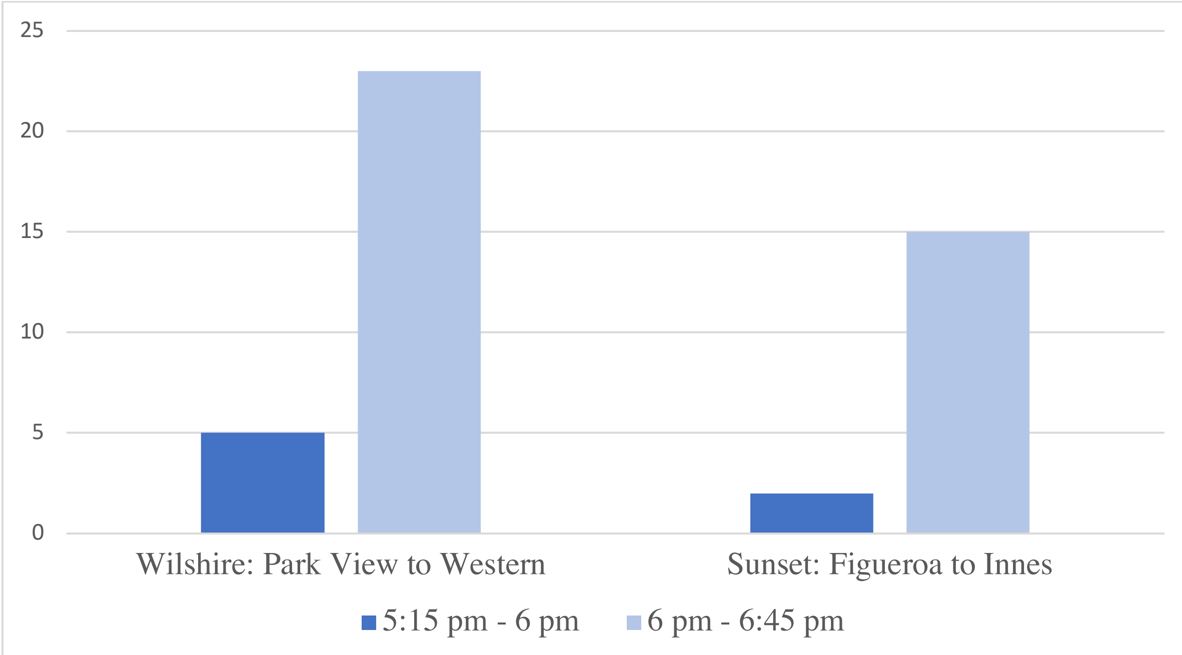
Sunset Boulevard: Figueroa Street to Innes Avenue

Sunset Boulevard's street designs prioritize vehicle speed and throughput with long blocks and limited pedestrian access points. The Sunset Boulevard bus lane operates EB Monday-Friday, 7 am – 9 am and WB 4 pm – 7 pm. On Wednesday, March 16th, 2022, I visited the site between 5:15 pm – 6:45 pm. For the initial half of my visit, much like on Wilshire Boulevard, I did not witness many obstructions or violations. In total, I observed two vehicles illegally using the lane and two vehicles illegally stopped in the lane for a period that could have obstructed a bus. And indeed, one of these vehicles did obstruct a bus. Between Custer Avenue and Figueroa Street, a car was illegally parked. The bus had approximately 500 feet to react and, with no cars travelling in the offset lane, seamlessly maneuvered around the parked car to continue using the bus lane. This was different than the struggling buses I saw make high-stress maneuvers around parked cars on Wilshire Boulevard.

Bus maneuvering around a parked car during bus lane hours on Sunset Blvd, between Custer Ave and Figueroa St. Source: author's photo, 2022

When I arrived at the segment of the bus lane with food destinations, however, I suddenly found clusters of parked cars. Of the 17 illegally parked vehicles I observed during my visit, 11 were clustered in front of a restaurant near Innes Avenue and a food stand near Marion Avenue. That is approximately 65% of all the illegally parked cars. This is worth highlighting considering this 0.1 mile stretch only makes up 17% of the 0.6-mile studied corridor. Additionally, there appears to be a correlation with bus lane obstruction, restaurants, and dinner time. Obstructions were far more common after 6 pm.

Figure 28: Cars Obstructing Bus Lanes During Operating Hours



What sets this segment of the study corridor apart from the rest of Sunset Boulevard is the existence of destinations. There is very little reason to want to stop or park on any other part of the corridor. The blocks between Marion Avenue and Beaudry Avenue host a night club and a church, both of which are closed during bus lane hours. The block between Beaudry Avenue and Custer Avenue hosts a major drug store and a fast food restaurant with a large, shared parking lot. The block between Custer Avenue and Figueroa Street serves as a freeway overpass. There is little reason for a car to stop in the bus lane on these other segments. The week I visited Sunset Boulevard, LADOT announced they were going to implement targeted enforcement of cars illegally parked in bus lanes by giving written warnings to motorists (City News Service, 2022). Yet, during my time on the corridor there was no enforcement presence. The parked cars I observed were idle for between 1-13 minutes. Unlike Wilshire Boulevard, though, these parked cars were easily skirted around by the bus drivers, who often saw the parked car well in advance and were able to merge into the next lane. Because the corridor prioritizes throughput, it was never difficult for the bus driver to execute and complete the maneuver.

The most dangerous moments on the corridor were when pedestrians interacted with motorists. Sunset Boulevard had far fewer pedestrians but a higher bicycle cohort than Wilshire Boulevard. The busiest pedestrian area was at Figueroa/Sunset. This area also happens to be the intersection with the most bus stops (four). Again, I found a correlation between high-pedestrian areas and transit. The crosswalk timers at this intersection gave no lead time for pedestrians. The pedestrian signal and green light for westbound drivers were synchronized. The time pedestrians had to cross the street fluctuated between 40-58 seconds. At this intersection, I also saw the highest number of bicyclists. Bicyclists on the corridor mostly used the bus lane. On one occasion, a bicyclist was riding in the center of the bus lane, forcing a bus to maneuver around it. Much like with parked vehicles, the bus was able to easily execute and complete its movement around the cyclist.

A bus maneuvers around a bicyclist traveling in the Sunset Blvd bus lane near Beaudry Ave.
Source: author's photo, 2022

The blocks on Sunset Blvd are incredibly long. Signalized pedestrian crosswalks are available approximately every 0.2 miles. This is starkly different from the signalized crossings on Wilshire Boulevard that are available approximately every 400 feet. The most dangerous moments on the corridor were the two occasions when a small group of pedestrians crossed Sunset Boulevard mid-block. High-collision areas are often characterized by having long blocks (Loukaitou-Sideris, et al, 2007). The two occasions occurred between Marion Avenue and Innes Avenue where I found the most destinations and bus lane obstruction. One group was leaving a bar to return to their cars in the restaurant parking lot. Another group was crossing to return to their curbside parked cars. In both cases, cars abruptly stopped for 5-10 seconds to allow the pedestrians to cross. These crossings felt extremely precarious. I attempted to cross the street mid-block myself near Marion Avenue, but the street's slight curvature made it difficult to be sure that I was not in danger of a speeding car.

Pedestrians attempting to cross midblock and a bus drives around a parked car blocking the bus lane, between Innes Ave and Marion Ave. Source: author's photo, 2022

The high number of bicyclists and low number of pedestrians align with the increase in bicyclist-involved collisions and decrease in pedestrian-involved collisions as indicated in the data. The corridor appears to have little pedestrian activity, resulting in fewer pedestrian-involved collisions. Nevertheless, the corridor's high-speed throughput, long blocks, and lack of controlled crosswalks make for higher street stress levels and collision frequencies.

Findings

The bus lanes on both of the segments I visited were identically accommodated, but the streets' land uses, configuration, and design made for different traffic safety outcomes. What I found on Sunset Boulevard was that it was not the moments of bus lane obstruction that were the tensest; but the brief moments when pedestrians interacted with the corridor's high-speed vehicles. This is not to suggest that streets should adopt the wide streets and fast speeds of Sunset Boulevard - Sunset Boulevard still experienced an increase in overall collisions and proportion of bicyclist-involved collisions. What this illustrates is that each street has their own specific challenges. These challenges should be met with proven, context-sensitive solutions. Wilshire Boulevard saw improvements on all the safety indicators, except bicyclist-involved collisions. As evident from my visit, the bus lane is not a sufficient bicycle facility, resulting in bicyclists using the sidewalk.

Comparatively, Sunset Boulevard saw improvements on all safety indicators, except bicyclist-involved *and* overall collisions. As evident from my visit, bicyclists experience a similar lack of bicycle facilities, and the bus lane is not doing enough to reduce vehicle throughput and speeds, resulting in a higher collision rate. The stark increase in collisions on Sunset Boulevard that I found in my data implies that the corridor's high level of throughput does not necessarily further street safety.

Policy and Planning Recommendations

Bus lanes alone will not increase safety. The introduction of peak hour bus lanes on Wilshire Boulevard and Sunset Boulevard resulted in divergent outcomes, with Wilshire Boulevard being the only studied segment with a decrease in collisions during bus lane hours. Figueroa Street saw collisions increase during bus lane hours even as it graduated from no bus lane, to a peak hour, to an all-day bus lane. But the accommodations made for Figueroa's all-day bus lane (including moving bicyclists into their own dedicated, painted lane) improved safety for bicyclists and reduced collisions overall during its peak hours. These findings imply that street safety cannot be addressed simply with a curbside, dedicated bus lane with "Bus Only" stenciled in white paint – be it peak hour or all-day. The Wilshire Boulevard Park View-Western bus lane is the only bus lane that saw a decrease in collisions. The accommodations made for the Park View-Western peak hour bus lane was no different than the other five segments analyzed on Wilshire Boulevard. Sunset Boulevard and Figueroa Street's peak hour bus lanes also saw near identical accommodations to those on Wilshire Boulevard. This implies that street designs on Park View-Western had a more pronounced effect on collisions compared to the other studied bus lanes segments. But, as the New York City and San Francisco case studies indicate, bus lanes can enhance street safety if installed in tandem with thoughtful, complementary design elements. Based on findings from my literature review, case studies, and a qualitative analysis of the Park View-Western segment, I make the following policy and planning recommendations:

Paint bus lanes red

A study analyzing white and red painted bus lanes found that red painted lanes were less likely to be obstructed and more likely to be frequently used by buses (Safran et al, 2014). A 2020 study discovered that existing passive enforcement techniques and design solutions were not sufficient for managing Los Angeles' bus lanes (Halls, 2020). In Summer 2021, LADOT piloted red thermoplastic paint on Wilshire Boulevard between Federal Avenue and Centinela Avenue, and Figueroa Street in Downtown LA (Meaney, 2022). In March 2022, a few targeted bus lanes in specific locations of Downtown LA were also painted red. Initial observations have found drivers to begin merging into the bus lane then react to the red paint by returning back to their designated lane (Linton, 2022).

Operate offset-running bus lanes
Studies around the globe including the U.S. have found that offset-running bus lanes are more efficient and increase street safety. A study in New York found that of all the possible bus lane configurations, offset bus lanes balanced transit, traffic and pedestrian needs the best by supporting pedestrian activity with the help of bus bulbs and curb extensions (both of which increase space for pedestrians while narrowing the roadway) (Beaton, et al, 2013).

Educate and encourage drivers not to illegally use the bus lane
A 2020 study found that drivers are rarely held accountable for illegally driving or stopping in the bus lane (Halls, 2020). In essence, despite the lane being deemed for buses, traffic patterns persist as if there was no bus lane at all.

For streets that allow curbside parking outside of bus lane operating hours, vehicles illegally park on the curb - forcing the bus to swerve out and back into the lane. This creates a shock to traffic flows as the large bus maneuvers into a lane with moving vehicles. A survey of bus operators found that most believe vehicle intrusions reduce roadway safety, increasing both their stress and the likelihood of collision (Halls, 2020). This is not to recommend armed or punitive enforcement of bus lane violators. Studies show that such enforcement disproportionately burden People of Color, causing financial strains and an expedited path to more fines, license suspensions and incarceration (Brazil, 2018). This is particularly of note considering the forthcoming NextGen bus lanes will serve communities of color such as West Adams, Mid City, MacArthur Park, and Historic Filipinotown. Bus lanes can be designed with distinct characteristics that make it clear not to drive or park in them. Los Angeles should develop passive enforcement design elements and non-punitive strategies to educate and encourage drivers not to drive in the bus lane when in operation.

Provide space to temporarily park on parallel or collector streets during bus lane hours
The majority of vehicles illegally obstructing the bus lane were from drivers briefly visiting a business. Specific areas with a high-level of commercial activity, especially restaurants, should be targeted with spaces to temporarily park for such brief stops. This would keep the bus lanes open and reduce the need for enforcement. New York City and San Francisco bus lanes provide space for parking on key commercial blocks by operating in the offset lane.

Limit the possibility for left turns
The center medians on Park View-Western occasionally block the ability of attempting a left turn. Alvarado Street also limits left turns at four of its five major intersections between 7th Street and the 101 Freeway. A report from LADOT found that left-turning fatal or severe pedestrian crashes outnumber right turning crashes by three to one (LADOT, 2017). Prohibited left turns at intersections are found to make streets safer (Duduta, et al, 2015) (NYCDOT, 2010). Left turns can be limited to major intersections

with turn signals. This allows for safer turns and reduces cars from queueing and blocking traffic.

Install center median strips or pedestrian islands on corridors
A major distinction between the Park View-Western segment and every other bus lane segment analyzed is the prevalence of a center median on the corridor. Center medians prevent interactions with vehicles travelling in the opposite direction and can provide a refuge for pedestrians crossing the street (Federal Highway Administration, n.d.). They are also found to reduce crash rates, especially those that end in fatal or severe injury (Portland Bureau of Transportation, 2017).

Install controlled crosswalks at intersections and on extensive blocks
Park View-Western segment has a high concentration of controlled intersections and short blocks. The other segments on Wilshire Boulevard, in contrast, have large blocks and fewer crosswalks for pedestrians. Installing more traffic signals at intersections helps control speeds and gives pedestrians more options to safely cross the street.

Future study of recent and forthcoming bus-only lanes and newly red painted lanes
Since 2019, at least seven new bus lanes have been installed in Los Angeles: Flower Street, 5th Street, 6th Street, Aliso Street, Olive Street, Grand Avenue, and Alvarado Street. They cover a broad range of street configurations (from bidirectional to one-way) and will vary from peak hour to all-day with some including dedicated bicycle facilities. For this study, only one all-day bus lane had ample enough data to analyze and none of the peak hour bus lanes studied were installed with a bicycle facility. Bus lane segments on Figueroa Street and Wilshire Blvd received red paint in 2021. Future analysis should be conducted on new and forthcoming Los Angeles bus lanes to measure how trends persist as bus lane installment continues to evolve across different streets and with different design elements.

Conclusion

Bus lanes are an effective tool to increase bus efficiency but require more than just a dedicated curbside lane to help improve street safety. Without design characteristics that communicate to drivers that the lane is not for their use, there is little inhibiting them from illegally driving or parking in the lane. Additionally, a lack of education and encouragement in Los Angeles further weakens the enhanced safety and efficiency that bus lanes in other cities experience. The increase in collisions that most of the studied bus lane segments saw is not evidence that the bus lanes are the cause. Rather, it is evidence that bus lanes should be given thoughtful consideration when they are installed and incorporate elements such as red paint, an offset lane, and complementary facilities for active transportation users to further enhance safety. Furthermore, I found a correlation with bus lanes and a reduction in severe and pedestrian-involved collisions – an outcome that was absent on my analysis of La Brea Ave, a street with no bus lane. Bus ridership has bounced back at a higher rate than rail ridership, nearing its pre-pandemic numbers (Walker, 2022). Bus riders are more likely to be low-income and People of Color (Hymon, 2020). Providing efficient bus services to communities of color who depend on it for their transportation needs is long overdue. But incorporating bus lanes in their communities must be done thoughtfully and effectively, and in tandem with complementary designs and accommodations for other users that promotes safe streets for all.

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Appendices

Appendix A: Quantitative Analysis Tables of Study Streets

Table 62: Wilshire Blvd: Collision Severity Between Park View St to Western Ave Before Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	39% (216)	43% (238)	15% (80)	2% (12)	1% (3)	549
Peak Hour	24% (37)	56% (88)	17% (27)	2% (3)	1% (1)	156
Total	36% (253)	46% (326)	15% (107)	2% (15)	1% (4)	705

Table 63: Wilshire Blvd: Parties Involved in Collisions Between Park View St and Western Ave Before Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	10% (54)	7% (40)	69% (381)	6% (35)	5% (31)	1% (8)	549
Peak Hour	17% (27)	5% (8)	76% (119)	0% (0)	1% (2)	0% (0)	156
Total	12% (81)	7% (48)	71% (500)	5% (35)	5% (33)	1% (8)	705

Table 64: Wilshire Blvd: Collision Severity Between Western Ave and San Vicente Before Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	31% (123)	45% (177)	19% (75)	4% (15)	<1% (2)	392
Peak Hour	23% (35)	50% (74)	23% (35)	3% (5)	0% (0)	149

Table 65: Wilshire Blvd: Parties Involved in Collisions Between Western Ave and San Vicente Blvd Before Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	10% (41)	11% (44)	68% (265)	4% (15)	5% (20)	2% (7)	549
Peak Hour	7% (10)	10% (15)	79% (118)	1% (2)	3% (4)	0% (0)	149

Table 66: Wilshire Blvd: Collision Severity Between Selby Ave and Veteran Ave Before Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	33% (36)	47% (51)	20% (22)	0% (0)	0% (0)	109
Peak Hour	25% (9)	64% (23)	11% (4)	0% (0)	0% (0)	36
Total	31% (45)	51% (74)	18% (26)	0% (0)	0% (0)	145

Table 67: Wilshire Blvd: Parties Involved in Collisions Between Selby Ave and Veteran Ave Before Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	6% (7)	6% (6)	84% (92)	1% (1)	1% (1)	1% (1)	109*
Peak Hour	8% (3)	8% (3)	83% (30)	0% (0)	0% (0)	0% (0)	36
Total	7% (10)	6% (9)	84% (122)	1% (1)	1% (1)	1% (1)	145*

*One collision was listed as a "non-collision". It accounted for approximately 1% of collisions during non-peak hours and 1% of total collisions

Table 68: Wilshire Blvd: Collision Severity Between Federal Ave and Centinela Ave Before Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	25% (32)	47% (61)	26% (33)	2% (3)	0% (0)	129
Peak Hour	15% (6)	56% (22)	26% (10)	3% (1)	0% (0)	39
Total	23% (38)	49% (83)	26% (43)	2% (4)	0% (0)	168

Table 69: Wilshire Blvd: Parties Involved in Collisions Between Federal Ave to Centinela Ave Before Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	10% (13)	7% (9)	77% (99)	6% (8)	0% (0)	0% (0)	129
Peak Hour	15% (6)	3% (1)	79% (31)	0% (0)	3% (1)	0% (0)	39
Total	11% (19)	6% (10)	77% (130)	5% (8)	1% (1)	0% (0)	168

Table 70: Sunset Blvd: Collision Severity Between Figueroa St and Innes Ave Before Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	33% (31)	40% (38)	23% (22)	2% (3)	0% (0)	94
Peak Hour	32% (13)	46% (19)	17% (7)	5% (2)	0% (0)	41
Total	33% (44)	42% (57)	21% (29)	4% (5)	0% (0)	135

Table 71: Sunset Blvd: Parties Involved in Collisions Between Figueroa St and Innes Ave Before Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	4% (4)	12% (11)	66% (62)	14% (13)	4% (4)	0% (0)	94
Peak Hour	12% (5)	5% (2)	73% (30)	2% (1)	7% (3)	0% (0)	41
Total	7% (9)	10% (13)	68% (92)	10% (14)	5% (7)	0% (0)	135

Table 72: Figueroa St: Collision Severity Between 23rd St and 6th St Before Peak Hour Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	38% (96)	42% (105)	17% (43)	2% (6)	0% (0)	250
Peak Hour	49% (27)	33% (18)	16% (9)	0% (0)	2% (1)	55
Total	40% (123)	40% (123)	17% (52)	2% (6)	>1% (1)	305

Table 73: Figueroa St: Parties Involved in Collisions Between 23rd St and 6th St Before Peak Hour Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	7% (17)	8% (19)	77% (193)	3% (8)	4% (10)	1% (3)	250
Peak Hour	7% (4)	5% (3)	82% (45)	4% (2)	2% (1)	0% (0)	55
Total	7% (21)	7% (22)	78% (238)	3% (10)	4% (11)	1% (3)	305

Table 74: Figueroa St: Collision Severity Between 23rd St and 6th St Before All-day Bus Lane Installation

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	46% (50)	29% (30)	23% (25)	1% (1)	0% (0)	79
Peak Hour	50% (14)	32% (9)	14% (4)	4% (1)	0% (0)	28
Total	47% (50)	28% (30)	24% (25)	2% (2)	0%	107

Table 75: Figueroa St: Parties Involved in Collisions Between 23rd St and 6th St Before All-day Bus Lane Installation

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	9% (7)	8% (6)	70% (55)	6% (5)	4% (3)	1% (1)	79
Peak Hour	4% (1)	21% (6)	68% (19)	4% (1)	4% (1)	0% (0)	28
Total	7% (8)	11% (12)	69% (74)	6% (6)	4% (4)	1% (1)	107

Table 76: Alvarado St: Collision Severity Between Beverly Blvd and Sunset Blvd (Dec. ’06 – Mar.’13)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	40% (128)	37% (118)	21% (68)	1% (3)	1% (3)	320
Peak Hour	36% (29)	46% (37)	14% (11)	5% (4)	0% (0)	81
Total	40% (157)	39% (155)	20% (79)	2% (7)	1% (3)	401

Table 77: Alvarado St: Parties Involved in Collisions Between Beverly Blvd and Sunset Blvd (Dec. ’06 – Mar.’13)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	7% (21)	5% (16)	79% (253)	6% (18)	4% (12)	0% (0)	320
Peak Hour	11% (9)	1% (1)	83% (67)	1% (1)	4% (3)	0% (0)	81
Total	7% (30)	4% (17)	80% (320)	5% (19)	4% (15)	0% (0)	401

Table 78: La Brea Ave: Collision Severity Between Pico Blvd and Sunset Blvd (May ’10 – Jan.’15)

	Property Damage Only	Complaint of Pain	Other Visible Injury	Severe Injury	Fatal	Total Collisions
Non-peak Hour	29% (154)	48% (253)	20% (104)	3% (16)	<1% (4)	531
Peak Hour	27% (41)	59% (91)	14% (21)	0% (0)	0% (0)	153
Total	29% (195)	50% (344)	18% (125)	2% (16)	<1% (4)	684

Table 79: La Brea Ave: Parties Involved in Collisions Between Pico Blvd and Sunset Blvd (May ’10 – Jan.’15)

	Pedestrian	Bicyclist	Motor Vehicle	Parked Car	Fixed Object	Other Object	Total
Non-peak Hour	6% (30)	6% (32)	78% (412)	5% (28)	5% (27)	<1% (2)	531
Peak Hour	7% (11)	4% (6)	86% (132)	2% (3)	0% (0)	<1% (1)	153
Total	6% (41)	6% (38)	80% (544)	5% (31)	4% (27)	<1% (3)	684

Appendix B: Wilshire Boulevard: Park View Street to Western Avenue Site Visit Photos

Parked car on Wilshire Blvd blocking the bus lane at 5:27 pm, between Normandie Ave and Mariposa Ave. Source: author's photo, 2022

Bicyclists traveling in the sidewalk in lieu of the bus lane at Wilshire Blvd and Normandie Ave. Source: author's photo, 2022

Appendix C: Sunset Boulevard: Figueroa Street to Innes Avenue Site Visit Photos

Sunset Blvd's wide thoroughfare is seven lanes. Source: author's photo, 2022

Meter parking on Sunset Blvd between Figueroa St and Custer Ave is nonoperational during bus lane hours. Source: author’s photo, 2022

Bicyclist traveling northbound in the bus lane, north of the intersection of Sunset Blvd and Beaudry Ave. Source: author's photo, 2022

Pedestrians carefully cross Sunset Blvd midblock to return to their curbside parked cars. Source: author's photo, 2022