FINAL REPORT
VERSION 2.0

SANDAG

I-15 EXPRESS LANES OPERATIONAL STUDY

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HNTB

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1. PURPOSE

This report summarizes the I-15 Express Lanes Operational Study. The study began with **Documentation of Existing Operations and Performance** involving three interrelated efforts. First, it established the vision for the I-15 Express Lanes and outlined a set of goals and objectives to support that vision. Second, it identified a series of performance measures to help quantify the goals and objectives. Third, it applied these performance measures to existing conditions in the I-15 corridor to understand the extent to which current operations support the goals and objectives.

The study then undertook the process of **Conducting an Operational Assessment**. The primary purpose of this effort was (a) to identify and define strategies for improving the operations and performance of the I-15 Express Lanes and (b) to evaluate the potential impact of these strategies on the performance measures defined earlier. The key question driving this phase of the study was: To what extent do the evaluated strategies support the goals and objectives for the corridor?

The final phase was to **Complete the I-15 Express Lanes Operational Study**. This portion of the study entailed the development of numerous wrap-up deliverables, including: (a) a sketch-level workplan outlining the key steps toward implementing the study's recommendations, (b) an Executive Summary of the study, (c) a presentation deck to be used by SANDAG staff for follow-up presentations, and (d) a detailed Final Report.

This report represents the "Final Report" cited above for the final phase of the I-15 Express Lanes Operational Study. It will highlight key elements regarding existing I-15 Express Lanes (EL) operations, and it will discuss potential benefits and impacts of selected strategies designed to improve SANDAG's ability to manage EL operations into the future. While this report will discuss operations in both the Express Lanes and the General Purpose (GP) lanes in the I-15 EL corridor, its focus will be on improvements to EL performance. This study has not considered adding physical capacity to the facility; rather, it has considered options for better enabling SANDAG to manage the demand on the existing facility. Therefore, the emphasis of this Final Report is not the identification of a strategy that improves conditions for all drivers. Rather, its emphasis is to provide SANDAG with the means to ensure that all drivers have an available option for a timely and reliable drive through the corridor if and when they need it.

2. PROJECT BACKGROUND

The I-15 corridor is the primary inland north-south transportation connector serving interregional travelers between Riverside County and downtown San Diego. It also is part of a major interregional goods movement corridor, connecting Mexico with Riverside and San Bernardino counties, as well as Las Vegas, Nevada. The San Diego Association of Governments (SANDAG), in partnership with the California Department of Transportation (Caltrans), operates and maintains the I-15 corridor.

The I-15 Express Lanes originated in 1988 as a 2-lane HOV2+ facility. It was 8 miles long and occupied the southernmost portion of the existing facility. The lanes were reversible, operating as two southbound lanes during the morning peak period and as two northbound lanes during the evening peak period. The lanes were converted to a High-Occupancy Toll (HOT) facility in 1998, in which single-occupant vehicles (SOVs) could use the lanes for a fee. The I-15 Express Lanes (EL) have operated in their current form (operating bi-directionally 24/7 as a continuous 20-mile corridor) since 2012. This award-winning facility has distinguished itself as one of the nation's most advanced

and innovative Express Lane systems. State Route (SR) 78 marks the northernmost point of the facility, while SR 163 represents the southernmost point. A detailed discussion of the existing operational environment of the I-15 Express Lanes corridor may be found in the *Existing Operational Environment Assessment Technical Memorandum*, found in **Appendix A**.

When tolling on I-15 began in 1998, the maximum fare for a full-length journey of 8 miles was $8. Vehicles only needed two occupants to travel for free. Vehicles that met the occupancy requirement (2 or more occupants), also known as High Occupancy Vehicles (HOV), could travel without a transponder. All of these policies—the maximum fare, the occupancy requirement, and the transponder requirement—have remained unchanged in the 22 years since the facility's inception, even as the span of the facility has more than doubled. The rise in usage, coupled with a capped maximum fare, has created three challenges that regularly recur on the facility:

- **Extensive violations:** Since transponders are not required and visual enforcement is difficult, many drivers take advantage and attempt to get a free ride. Surveys conducted by SANDAG over the past couple of years have indicated that 25-30% of users of the Express Lanes are violators—meaning, single-occupant vehicles driving through the Express Lanes without a transponder.
- **Northbound Express Lanes congestion:** The evening commute is not as reliable as it once was, as the Express Lanes—congested in part by unauthorized users—frequently slow down. It is common to encounter speeds in the 25-30 miles per hour (mph) range during peak periods.
- **Frequent HOV Only:** With some regularity, congested traffic conditions automatically force the Express Lanes into "HOV ONLY" mode which only allows vehicles with 2 or more occupants to enter the Express Lanes. During such periods, the Express Lanes no longer provide a reliable ride for single-occupant vehicles that wish to pay for the service.

These operational challenges highlight the importance of establishing a fresh vision for the I-15 Express Lanes. This would serve as the foundation of the I-15 Express Lanes Operational Study.

3. ANALYTICAL FRAMEWORK

At the outset of the I-15 Express Lanes Operational Study, SANDAG established a detailed framework for assessing operations and recommending improvements. This framework is summarized briefly in the bullets below:

- **Step 1 –** Establish a vision for the I-15 Express Lanes corridor. Then, identify a set of goals and objectives that support the vision in tangible ways.
- **Step 2 –** Define performance measures that can evaluate the extent to which the goals and objectives (identified in Step 1) are being met.
- **Step 3** – Evaluate existing conditions in the I-15 Express Lanes corridor in light of the performance measures defined in Step 2. This evaluation will highlight specific ways in which the Express Lanes, as currently operated, are supporting the goals and objectives established for the corridor and where there are opportunities for improvement.
- **Step 4** – Identify some specific strategies for addressing the shortcomings identified in the existing conditions analysis (Step 3).
- **Step 5 –** Develop and employ a spreadsheet model to assess the extent to which the evaluated strategies could improve the noted shortcomings.

- **Step 6 –** Recommend a specific strategy (or multiple strategies) and begin drafting a sketch-level implementation plan.

Steps 1 through 4 were undertaken as part of the initial analysis of the I-15 Express Lanes Operational Study (**Documentation of Existing Operations and Performance**), while **Steps 5 through 6** were part of the second analysis (**Conduct Operational Assessment**). A follow-up phase of the study (not yet commenced) will consider non-operational impacts, such as social equity.

The sections that follow will review this analytical framework in more detail.

4. ESTABLISH VISION, GOALS AND OBJECTIVES

The I-15 Express Lanes Operational Study began with a Visioneering Workshop designed to establish the Corridor Management Team (CMT)'s vision for the I-15 corridor and to outline the more tangible goals and objectives that would support this vision.

VISION

The CMT— comprised of fifteen members representing SANDAG, Caltrans, the Metropolitan Transit System, and other regional partners—developed the following I-15 Vision Statement:

Provide a world class transportation facility that:

- Provides a safe, reliable, and predictable commute for I-15 Express Lanes customers;
- Provides easy to use travel options without barriers that meet the needs of today while also sustaining future growth and evolution in travel options;
- Has regionally consistent business rules and operating policies;
- Is aligned with Caltrans' & SANDAG's Mission and Vision;
- Strengthens successful partnerships with SANDAG, Caltrans, MTS and other stakeholders;
- Is a model for other Express Lanes corridors in the region; and
- Complements I-15 General Purpose (GP) Lane operations

GOALS

Following the development of the vision for the I-15 Express Lanes, the CMT defined specific *goals*. These goals, which describe milestones to be achieved in support of the vision, are summarized below:

- Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls
- Generate sufficient revenue to sustain I-15 Express Lanes operations
- Minimize operation and maintenance (O&M) costs

OBJECTIVES

The purpose of an *objective* is to translate the goals' general statements into quantifiable and measurable results. The objectives outlined for the I-15 Express Lanes Study are as follows:

- Optimize and maintain I-15 Express Lanes trip reliability
- Reduce I-15 corridor (GP and EL) person and/or vehicle delay

- Improve I-15 corridor (GP and EL) person and/or vehicle throughput
- Improve efficiency in the Express Lanes
- Improve transit service performance
- Reduce incidents and associated travel delays

Details related to the vision, goals and objectives for this corridor can be found in the *I-15 Express Lanes Corridor Management Team Vision Technical Memorandum*, located in **Appendix B**.

5. DEFINITION OF PERFORMANCE MEASURES

Based on the CMT's vision, goals and objectives, a set of performance measures was defined for the study. These performance measures would be used to evaluate existing operational performance as well as to assess the impact that various operational strategies could have on the corridor's operations. These measures—developed in collaboration with SANDAG and Caltrans and summarized in **Table 1**—are consistent with evaluating the goals and objectives identified in the CMT Charter (as summarized above).

Table 1 breaks the performance measures down into three broad categories—those that deal with operations within the Express Lanes themselves, those that deal with operations in the GP lanes, and those that deal more broadly with I-15 corridor-wide operations.

Table 1 – Proposed Performance Measures for Monitoring I-15 Corridor Operations

EXPRESS LANES OPERATIONS	GP LANES OPERATIONS	I-15 CORRIDOR-WIDE OPERATIONS
▪ % of EL vehicles traveling as SOVs ▪ % of EL vehicles carrying 2 people (HOV2) ▪ % of EL vehicles carrying 3+ people ▪ % of EL *people* traveling as HOV3+ ▪ EL travel times (daily & peak period) ▪ EL speeds ▪ EL 90th percentile travel times ▪ Frequency & duration of HOV ONLY events ▪ EL vehicle-hours of travel (VHT) ▪ EL vehicle-hours of delay (VHD) ▪ EL vehicle-miles traveled (VMT) ▪ EL vehicle throughput ▪ EL person throughput ▪ EL violation rate	▪ GP speeds ▪ GP travel times (daily & peak period) ▪ GP VHT ▪ GP VHD ▪ GP VMT ▪ GP vehicle throughput	▪ Express Lanes gross revenue ▪ Est. EL operating costs ▪ Est. net revenue (gross revenue less operating costs) ▪ Annual average cost per EL trip served ▪ # of FasTrak transponders & active accounts ▪ Average FasTrak user trip length ▪ # of travel incidents per year from CHP ▪ Transit ridership ▪ Transit on-time performance ▪ Transit peak load factor

A more detailed discussion of these performance measures, including a table mapping the performance measures to their corresponding goals and objectives, may be found in the *I-15 Express Lanes Operational Study Performance Measures Technical Memorandum*, located in **Appendix C.**

6. EVALUATE EXISTING CONDITIONS

HNTB's analysis began with a detailed assessment of all performance measures under existing conditions. The purpose of this initial analysis was to establish a baseline to which all evaluated strategies could be compared. To this end, hourly and monthly traffic data was gathered from TransCore's Account Management Systems (AMS) for the ELs and from Caltrans' Performance Measurement System (PeMS) for the GP lanes. This data was summarized to identify variations in traffic demand from 2017 through early 2019. Similarly, median and planning time speeds were analyzed using speed heat maps for all recorded EL trips in the datasets in 5-minute increments by direction. Travel time reliability was analyzed by estimating the range of observed travel times (the lower bound and upper bound were used to determine the travel time for 10 percent and 90 percent of vehicles, respectively, that experience a specific travel time or faster) for a through trip on the ELs for an average weekday. These were used to illustrate the degree of consistency and travel time dependability of the ELs.

Vehicle occupancy survey data provided by SANDAG was used to estimate the HOV/SOV split on the ELs, to estimate the percentage of persons in HOVs, and to develop estimates for vehicle miles of travel (VMT) and vehicle hours of delay (VHD) for ELs in the peak periods. Estimated revenue, EL operating costs and the average cost per EL trip were summarized using data provided by SANDAG (and from AMS). Based on data provided by SANDAG and MTS, violation rates and transit parameters (including ridership and average peak load factors for routes using the I-15 corridor) were estimated. Finally, the trends for average typical EL trip lengths and frequency of occurrence of HOV-only mode were analyzed.

A brief summary of some key performance measures is illustrated in **Table 2**. The values for these performance measures provide a baseline against which alternative strategies could be compared.

Table 2 – Key Performance Measures, Existing Conditions

PERFORMANCE MEASURE	APPLICABLE LOCATION			
	Via Rancho Pkwy *(north)*	Carmel Mtn Rd. *(central)*	Miramar Way *(south)*	Corridor-Wide
1. EL vehicle throughput, *average daily basis*	46,103	45,604	46,510	
2. EL vehicle throughput, *peak period*[*]	4,710	4,639	5,114	
3. GP lanes vehicle throughput, *average daily basis*	211,475	225,994	260,379	
4. GP lanes vehicle throughput, *peak period*[*]	16,330	15,055	15,653	
5. EL person throughput, *average daily basis*	79,758	78,895	79,997	
6. SOV mode share in EL, *average daily basis*	32.6%	28.4%	25.1%	
7. HOV2 mode share in EL, *average daily basis*	44.0%	40.4%	43.8%	
8. HOV3+ mode share in EL, *average daily basis*	8.0%	3.9%	5.7%	
9. HOV3+ people share in EL, *average daily basis*	15.3%	8.1%	11.4%	
10. Ave. EL speed (in mph), *peak period*[*]	62.0	65.0	68.0	
11. Ave. travel time thru EL (minutes), daily basis				16.4
12. Ave. travel time thru EL (minutes), peak period[*]				18.9
13. Ave. speed in GP lanes (in mph), peak period[*]	41.0	48.0	39.0	
14. Ave. travel time thru GP lanes (minutes), daily basis				19.4
15. Ave. travel time thru GP lanes (minutes), *peak period*[*]				29.6
16. EL gross revenue (in $millions), *annual basis*				$11.6

[*]*Throughout this table, the term "peak period" refers to the period in which two-way Express Lanes volumes are at their highest. Though the exact timing varies from day to day, the peak period typically occurs at some point on weekdays between 3pm and 5pm.*

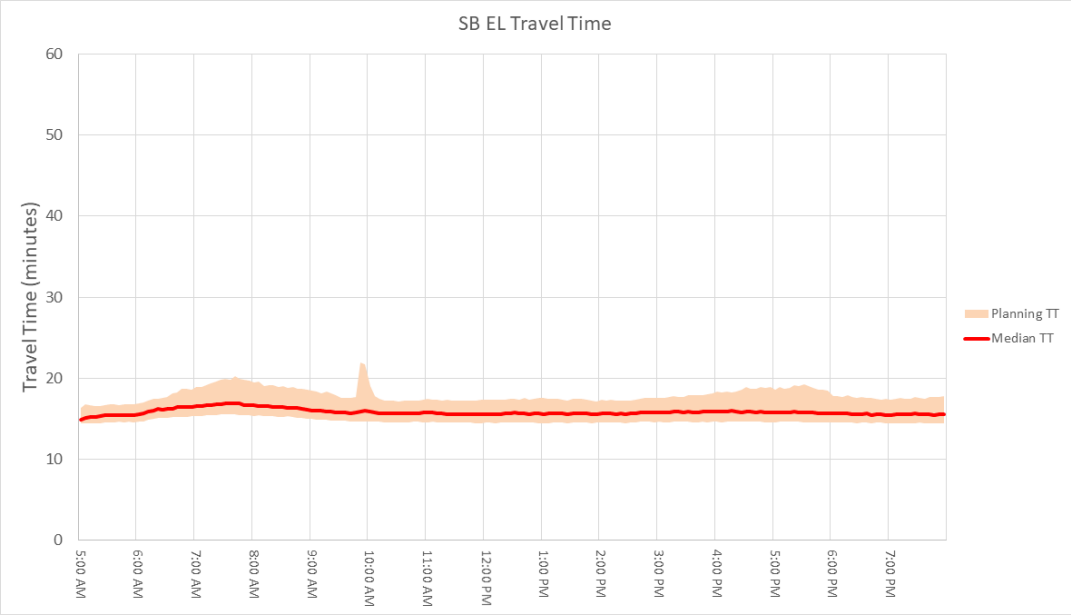
A detailed treatment of all performance measures under existing conditions may be found in the *Existing Operational Performance Analysis Technical Memorandum*, located in **Appendix D**.

Based on the analysis conducted on the performance measures, HNTB identified five themes that encapsulate key observations of the I-15 Express Lanes existing conditions analysis. These themes are summarized on next page:

THEME 1: Southbound (SB) ELs are rarely congested in the AM peak period, resulting in high throughput and reliable travel times.

A detailed review of travel time through the SB Express Lanes shows that conditions are quite reliable, even during peak periods. This is illustrated in Figure 1, which depicts travel time reliability throughout the day. The red line shows the median travel time, while the yellow band highlights the range of times experienced throughout the day. The upper limit of the yellow band is the 90th percentile travel time (i.e. 90% of drivers experienced a time that was equal to or less than this), while the lower limit of the yellow band is the 10th percentile travel time (i.e. 10% of drivers experienced a time that was equal to or less than this). In other words, 80% of all trips occur within the time highlighted by the yellow band. The upper limit of the yellow band may be referred to as the "planning travel time"—that is, a conservative estimate of travel time for planning purposes.

Figure 1 – Travel Time Reliability in I-15 Express Lanes, Southbound Direction



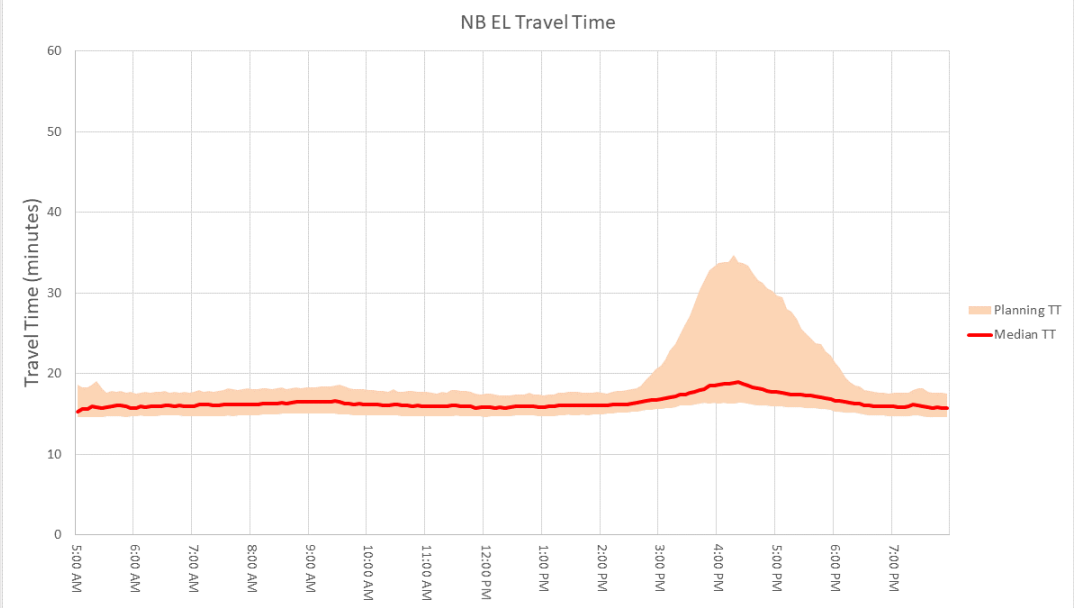
The chart reveals three key characteristics of SB travel through the Express Lanes:

- The median travel time stays consistently in the vicinity of 16-17 minutes throughout the day.
- The planning travel time almost never exceeds 20 minutes. With almost complete certainty, drivers traveling the full length of SB I-15 Express Lanes can rely on a ride that takes 15-20 minutes to complete, regardless of the time of day.
- The planning travel time experiences a sharp but brief rise at 10am. This appears to coincide with the movement of the southbound barrier. However, the problem does not appear to be acute. The median travel time at 10am rises only slightly, indicating that the inconvenience to drivers is not widespread or of long duration.

THEME 2: Northbound (NB) EL's are frequently congested during the PM peak, resulting in low throughput and unreliable travel times.

The same level of reliability is *not* seen in the NB I-15 Express Lanes. Although the median travel time for NB trips is similar to the median travel time for SB trips, the *variability* experienced by NB drivers in the Express Lanes is much greater. This is illustrated by **Figure 2**, which—just as **Figure 1** did for SB trips—depicts the median and planning travel times for a NB trip through the 20-mile length of the corridor.

Figure 2 – Travel Time Reliability in I-15 Express Lanes, Northbound Direction



The following observations may be drawn from **Figure 2**:

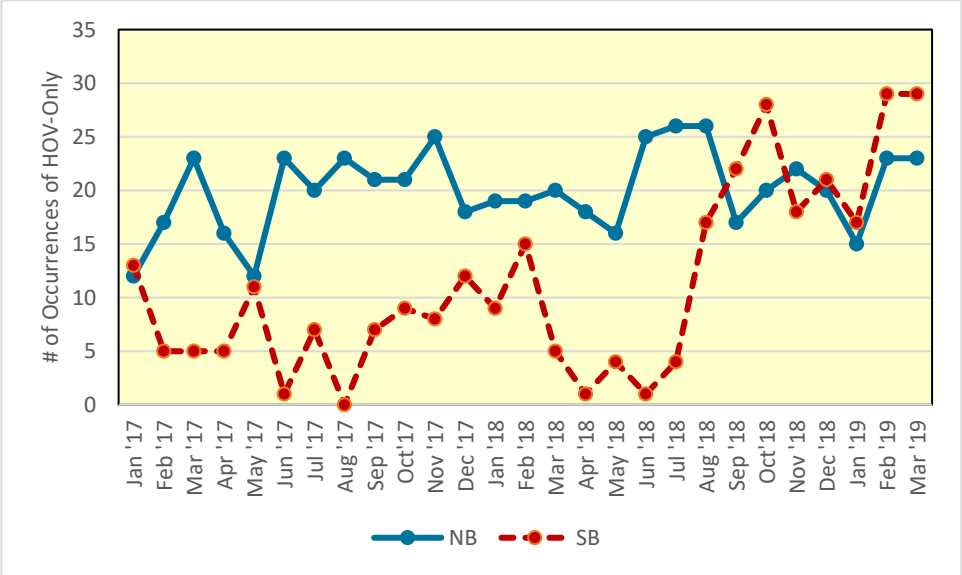
- In the PM peak (covering the period from 3pm to 6pm), the median travel time increases to a high of approximately 19 minutes. This is only slightly higher than the peak SB time of approximately 17 minutes, and it still reflects an average speed of approximately 60 mph.
- However, the planning travel time (as indicated by the upper limit of the yellow band) reaches as high as 33 minutes. This means that, during the heart of the evening peak period, about 10% of drivers in the NB Express Lanes are experiencing travel times of 33 minutes or more. This is twice the travel time duration experienced by NB drivers during non-peak periods.

The broad band of travel times depicted in **Figure 2** indicate that PM peak period travel in the Express Lanes is not reliable in the NB direction.

THEME 3: Occurrences of "HOV Only" in the southbound direction have significantly increased since June 2018.

Historically, the number of occurrences of "HOV Only" were higher for the northbound direction compared to the southbound. However, occurrences of "HOV Only" in the southbound direction have significantly increased since June 2018. This is illustrated by **Figure 3**, which shows how the number of "HOV Only" occurrences (on a monthly basis) changed from January 2017 through March 2019.

Figure 3 – Trends in the Number of HOV ONLY Occurrences, NB vs. SB



Prior to August 2018, the SB Express Lanes typically recorded 10 or fewer "HOV Only" events per month. Meanwhile, the NB Express Lanes were recording 15-25 "HOV Only" events per month. But starting in August 2018, the SB number climbed dramatically, to the point that it is now on par with the number of NB "HOV Only" events. Since "HOV Only" events are typically triggered by congestion, this is perhaps a leading indicator that SB traffic operations in the Express Lanes are degrading.

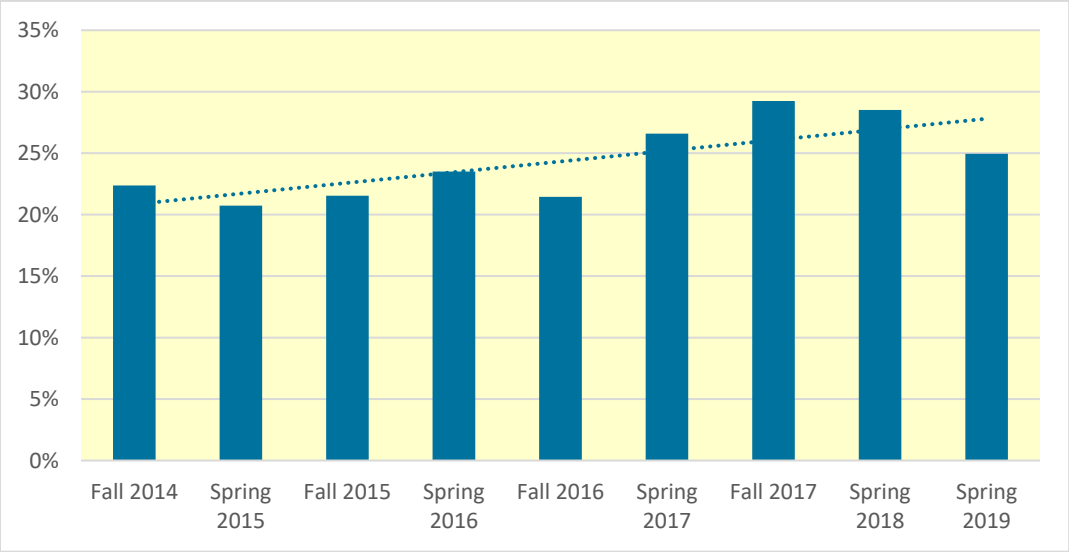
Please note that a more detailed look at the data indicates that NB occurrences averaged about 80 minutes in duration. Meanwhile, SB occurrences have averaged roughly 30 minutes in duration, and this average duration has not changed even though the *number* of occurrences has increased. It is possible that the shorter duration in the SB direction can be attributed to the extra lane during peak periods, which makes a quicker recovery possible.[1]

[1] Recall that the southern 16 miles of the I-15 Express Lanes are configured with 3 SB lanes and 1 NB lane during the morning peak period. During the evening peak period, the lanes are configured with 2 NB lanes and 2 SB lanes.

THEME 4: Violations Rates have steadily increased since 2014.

SANDAG periodically commissions visual surveys of the I-15 Express Lanes to identify the percentage of drivers who use the lanes as a single-occupant vehicle (SOV) without having a mounted, valid transponder to pay for the trip. As **Figure 4** illustrates, the share of violations is high and trending upward.

Figure 4 – Violation Rate Trends, Fall 2014 through Spring 2019

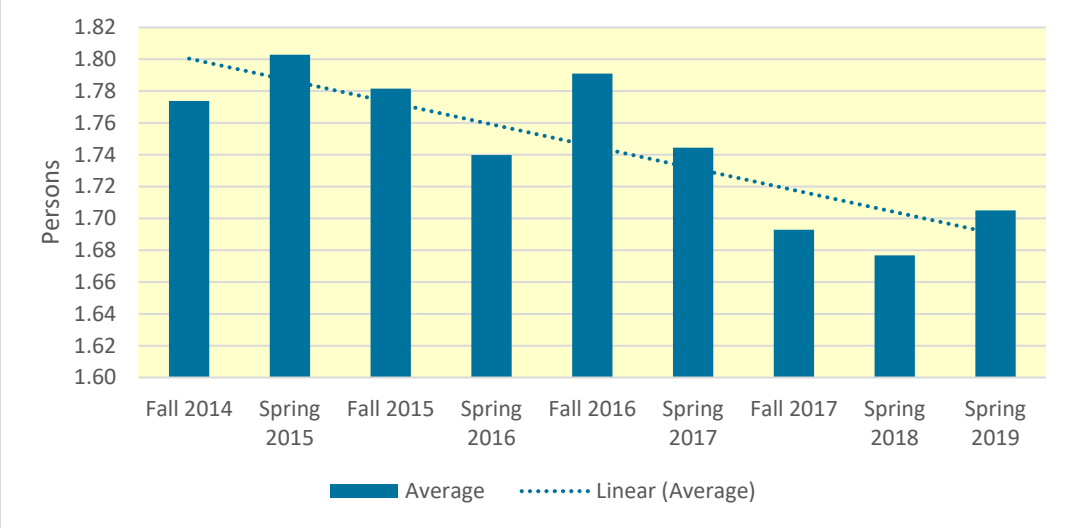


In other words, the share of violations has grown from about 20% (as captured in late 2014/early 2015) to over 25% in more recent times. These unauthorized users provide both a drain on revenue and a strain on operations.

THEME 5: Vehicle occupancy remains low (at most locations, SOV comprise more than 40% of vehicles, and less than 10% of vehicles are HOV 3+ during the peak periods in the peak direction).

The last key theme emerging from the analysis of existing conditions is that vehicle occupancy in the I-15 Express Lanes is fairly low and is trending downward. This is illustrated by **Figure 5**, which depicts vehicle occupancy trends from late 2014 through early 2019.

Figure 5 – Vehicle Occupancy Trends, Fall 2014 through Spring 2019



As **Figure 5** indicates, average occupancy has declined from 1.8 in early 2015 to about 1.7 in early 2019. In other words, the average vehicle in the I-15 Express Lanes has less than 2 occupants and the value appears to be getting smaller over time, indicating more single-occupant vehicles. Although the average of 1.7 occupants per vehicle is in line with national averages,[2] the number certainly indicates that there is potential to increase *person* throughput without changing *vehicle* throughput.

A more detailed discussion of each theme may be found in the *Existing Operational and Performance Conditions Report*, located in **Appendix E**. The **Documentation of Existing Operations and Performance** portion of the I-15 Express Lanes Operational Study concluded with the identification of these themes.

[2] FHWA recommends that planners use an average occupancy factor of 1.7 for all vehicles. For more details, see https://www.fhwa.dot.gov/tpm/guidance/avo_factors.pdf. (Site accessed 4/2/2020)

7. IDENTIFY SPECIFIC STRATEGIES FOR ADDRESSING SHORTCOMINGS

The **Conduct Operational Assessment** portion of the I-15 Express Lanes Operational Study began with the project team identifying three operational strategies to assist the CMT with achieving the vision, goals and objectives for the I-15 corridor. HNTB evaluated each strategy in terms of its ability to improve the existing operational deficiencies documented earlier and encapsulated by the 5 Themes. These strategies included the following:

- **Strategy #1 – Transponder for All**. This strategy requires all users of the EL to have a transponder, regardless of the number of occupants. The new transponder requirement would be accompanied by enhanced video enforcement.
- **Strategy #2 – Change HOV Eligibility**. This strategy increases the required number of occupants (for toll-free travel) from HOV2+ to HOV3+.
- **Strategy #3 – Increase Maximum Toll**. This strategy permits the toll rate to increase above the current maximum of $8 per trip. It maintains the current per-mile maximum of $1 but allows the per-mile rate to be applied to the full length of the trip. Since a full-length trip is 20 miles, this strategy essentially increases the maximum toll from $8 to $20.

HNTB's analysis focused primarily on the first two strategies, evaluating their anticipated impact on each of the performance measures documented in **Table 2**. HNTB's assessment of Strategy #3 includes a high-level analysis of the expected operational and revenue impacts; however, data relative to Strategy #3 is not currently available to detail the likely impacts to the performance measures defined for this study. A comprehensive analysis of Strategy #3 requires a detailed understanding of origin-destination movements—and the toll rates assessed to vehicles making those movements—during peak periods. This level of data was not available for the study.

All strategies were assessed independently; HNTB's analysis did not assess the impacts of implementing multiple strategies simultaneously. Future study will need to do the following:

- Evaluate the potential for combining strategies;
- Evaluate the optimal timing by which each strategy may be implemented; and,
- Pursue a more detailed assessment of Strategy #3, incorporating more detailed tracking of origin-destination movements during peak periods (i.e. the time in which this strategy would impact toll rates).

8. EVALUATE THE STRATEGIES

HNTB's next step was to develop and employ a spreadsheet modeling tool to evaluate the ability of the aforementioned strategies to address the operational problems identified in the analysis of existing conditions. **Table 3** summarizes the impact of **Strategies #1 and #2** on each key performance measure. Cells that are shaded green and have bold font indicate results that are clearly favorable to achieving the corridor's vision, goals, and objectives. As noted in the previous section, sufficiently detailed data was not available to enable this same analysis to be performed for **Strategy #3**. Also, as discussed in the footnote to **Table 2**, please note that the term "peak period" refers to the hour (typically occurring at some point between 3pm and 5pm, depending on location) during which two-way Express Lane traffic is at its peak.

Table 3 – Performance Measure Summary for Strategies 1 and 2

Performance Measure	Strategy #1 *Transponders for All*	Strategy #2 *Increase HOV Requirement*
1. EL vehicle throughput, *average daily basis*	Reduction of 17-22%	Reduction of 10-11%
2. EL vehicle throughput, *peak period*	Reduction of 19-23%	Reduction of 11-12%
3. GP lanes vehicle throughput, *average daily basis*	Increase of 3-5%	Increase of 2-3%
4. GP lanes vehicle throughput, *peak period*	Increase of 6-7%	Increase of 4-5%
5. EL person throughput, *average daily basis*	Reduction of 20-23%	Reduction of 13-14%
6. SOV mode share in EL, *average daily basis*	Increase of 15-20%	Increase of 7-8%
7. HOV2 mode share in EL, *average daily basis*	Reduction of 3-5%	Reduction of 18-19%
8. HOV3+ mode share in EL, *average daily basis*	Reduction of <1%	**Increase of 3-4%**
9. HOV3+ people share in EL, *average daily basis*	Reduction of 1-2%	**Increase of 8-9%**
10. Ave. EL Speed (in mph), *peak period*	**Increase by 1-7 mph (2-11%)**	**Increase by 1-5 mph (1-8%)**
11. Ave. travel time thru EL (minutes), *daily basis*	**Reduce by 2%**	**Reduce by 1%**
12. Ave. travel time thru EL (minutes), *peak period*	**Reduce by 7%**	**Reduce by 5%**
13. Ave. speed in GP lanes (in mph), *peak period*	Reduce by 1-5 mph (2-12%)	Reduce by 0.5-3 mph (1-8%)
14. Ave. travel time thru GP lanes (minutes), *daily basis*	Increase by 3%	Increase by 2%
15. Ave. travel time thru GP lanes (minutes), *peak period*	Increase by 15%	Increase by 9%
16. EL gross revenue (in $millions), *annual basis*	**Increase by 25-35%**	**Increase by 80-90%**

A high-level review of **Strategy #3, Increase Maximum Toll**, indicated the following:

- This strategy allows for higher tolls to be applied to longer trips (i.e. trips >8 miles in length). Such trips account for about 50% of all EL trips and approximately 80% of all EL VMT.
- Consequently, this strategy enables SANDAG to exercise greater control over the users of the EL facility. This strategy would yield the following benefits:
    - **Improved operations.** SANDAG could exercise greater price control to maintain an acceptable level of service during peak periods.
    - **Reduced HOV ONLY mode**. Improved operations make it less likely that conditions would deteriorate to the point that a reversion to HOV ONLY would be required.

  - **Increased revenue.** An initial analysis indicates that the average peak-period rate (6:30am-8:30am SB, 3:30pm-5:30pm NB) would increase by roughly 50%. This would increase weekday revenue by approximately 20%.
  - **Increased HOV mode share in EL.** This strategy only applies to SOVs, meaning that only SOVs would divert as a result of potentially higher toll rates. As a result, the mode share of HOVs in the Express Lanes would increase.

- It is possible that increasing the maximum toll would provide a greater incentive for SOVs to become violators. However, if this strategy were implemented in conjunction with **Strategy #1,** then the enhanced enforcement associated with Strategy #1 would likely mitigate any growth in violations. This in turn would promote HOV utilization of the Express Lanes as well as improve the ability to manage the corridor.

Although HNTB's analysis indicated that **Strategy #3** could be an extremely effective tool in managing demand and improving EL operations, a more detailed analysis will be required before moving forward to implementation. This is because detailed data regarding toll rates during peak hours was not available for this Phase 1 analysis. To truly understand the potential impact of this policy, it will be necessary to know the toll rates that are currently in effect during peak periods. And these rates will need to be provided for each possible trip in the Express Lanes, so that we can understand the frequency with which the current rate limit of $8.00 per trip is imposed. The high-level data received by HNTB suggests that this current limit is a significant constraint on trip-based pricing. Nevertheless, this will need to be confirmed with detailed origin-destination toll data before moving forward.

Appendix G, entitled *Operational Strategy Performance Findings Technical Memorandum*, provides a detailed discussion of the estimated impact of the evaluated strategies on each performance measure. It also contains a more extended discussion of the extent to which the evaluated strategies better enable SANDAG to achieve the vision, goals, and objectives established at the outset of the study. The results reported in the *Operational Strategy Performance Findings Technical Memorandum* and this Report should serve only as a reference point. While other agencies have implemented similar strategies, SANDAG should prepare for varied results due to several factors that could influence the impact of these strategies. Factors that promote proposed improvements and operational changes, such as public information and marketing campaigns, should be examined in more detailed during the development of an Implementation Plan noted below.

A review of the three strategies evaluated in this portion of the study indicates that each addresses the "5 Themes" observed in the existing conditions analysis. The strategies enhance the operational strengths as well as address the operational shortcomings revealed by these themes. This is illustrated by the following:

- **Theme 1** noted that the SB Express Lanes perform very well during the AM peak period, exhibiting both high throughput and reliable travel times. By providing improved enforcement **(Strategy #1)** and an enhanced ability to apply greater price control when needed **(Strategy #3)**, these strategies provide SANDAG with the tools needed to sustain excellent service and therefore prevent degradation over time.
- **Theme 2** identified frequent Express Lane congestion in the NB peak period, with some drivers experiencing travel times of over 30 minutes for a full-length trip through the corridor. **Strategies #1 and #2** demonstrated that they could reduce peak-period travel times by 5-7%. **Strategy #3**

would almost certainly improve NB travel times by providing SANDAG with a greater ability to exert price control over full-length trips. Greater control will in turn facilitate more reliable travel times in the Express Lanes.

- **Theme 3** identified a growth of "HOV Only" occurrences in the SB direction. These occurrences are likely being driven by increasing SB traffic levels during peak periods. HNTB's analysis indicated that **Strategy #1** could reduce AM peak-period volumes in the SB Express Lanes by 15-20%, while **Strategy #2** could achieve a 6-9% reduction. The resultant reduction in congestion would lead to a decreased occurrence of "HOV Only" mode. **Strategy #3** — which enables SANDAG to assess higher tolls for long-distance trips during peak periods — would also enhance SANDAG's ability to manage growing SB volumes and therefore reduce "HOV Only" occurrences.
- **Theme 4** highlighted the elevated and increasing incidence of violations. **Strategy #1**, with its emphasis on increased video enforcement in conjunction with requiring transponders, would put great downward pressure on the violation rate. HNTB's analysis indicates that the violation rate would fall into the 7-10% range, a significant drop from current levels that hover around 25%.
- **Theme 5** noted that average vehicle occupancy levels in the I-15 Express Lanes were relatively low and getting lower over time. **Strategy #2** takes aim at this phenomenon by incentivizing HOV3+ travel. HNTB's analysis suggests that **Strategy #2** would increase the share of people traveling in HOV3+ vehicles by 8-9%. And **Strategy #3**, by facilitating higher fares for longer SOV trips, would almost certainly produce an increase in the share of HOVs.

In short, the strategies identified by this study would address key operational shortcomings in the I-15 Express Lanes. Moreover, they would enhance the CMT's ability to achieve its vision, goals and objectives for the corridor. **Table** 4 summarizes the manner in which the evaluated strategies support the CMT's goals and objectives.

As regional growth continues and the demand for a reliable travel time increases, these strategies will become increasingly necessary to prevent the Express Lanes operations from degrading to a point where they provide little benefit compared to the GP lanes. This study has shown that these operational strategies can offer motorists an option for a reliable travel time. Furthermore, the operational strategies considered in this evaluation will incentivize carpooling while regulating demand and improving key sustainability metrics such as VMT and greenhouse gas emissions.

Table 4 – Impact of Selected Strategies on CMT's Goals & Objectives

	Goals & Objectives	Positive Impact Summary
Goals	**Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers**	▪ The strategies collectively enable SANDAG to more effectively manage Express Lane traffic, thus reducing occurrences of HOV ONLY mode. As a result, capacity is preserved for all prospective users of the facility, both HOV and non-HOV.
	Generate sufficient revenue to sustain I-15 Express Lanes operations	▪ All strategies were found to enhance revenue, thus ensuring that SANDAG has a reliable income stream that should continue to sustain revenue for years to come.
	Minimize operations and maintenance (O&M) costs	▪ The *Transponder for All* strategy will demonstrably reduce violations. This in turn will help reduce O&M costs, since violations are far more expensive to pursue than valid transactions.
Objectives	**Optimize and maintain I-15 EL trip reliability**	▪ All strategies were found to reduce congestion and therefore improve travel times and trip reliability in the I-15 Express Lanes.
	Reduce I-15 corridor person and/or vehicle delay	▪ All strategies were shown to reduce delays experienced in the I-15 Express Lanes.
	Improve I-15 corridor person and/or vehicle throughput	▪ Vehicle throughput is typically a concern during peak periods. By enhancing SANDAG's ability to manage capacity in the I-15 Express Lanes, all strategies help ensure a steady and reliable flow of traffic during peak periods. By enabling SANDAG to avoid "gridlock" conditions in the Express Lanes, the proposed strategies have the potential to improve throughput during peak periods.
	Improve efficiency in the I-15 EL	▪ All strategies enhance SANDAG's ability to manage capacity in the I-15 Express Lanes, thus ensuring an efficient flow of traffic during peak periods and reducing interruptions to service caused by reversion to HOV ONLY mode.
	Improve transit service performance	▪ Improved efficiency in the I-15 Express Lanes will also improve service levels experienced by transit customers in the EL
	Reduce incidents and associated travel delays	▪ The analysis could not forecast the ability of the strategies to reduce incidents. However, by improving SANDAG's ability to manage demand, these strategies provide the tools to better avert travel delays for all EL customers during periods in which incidents in the GP lanes may occur.

9. CONCLUSIONS AND RECOMMENDATIONS

As HNTB's examination of the I-15 Express Lanes indicated, there are deficiencies in the existing I-15 corridor operations. During the evening peak period on weekdays, the I-15 Express Lanes do not provide a reliable ride, with full-length travel times occasionally rising to over 30 minutes. In the SB direction, reversion to "HOV Only" mode is becoming increasingly common. One out of four users of the facility are violators—a single-occupant vehicle who should be paying but is not—and vehicle occupancy is relatively low and declining. In short, some aspects of performance are not satisfactory and are trending in the wrong direction. This jeopardizes the ability of the I-15 Express Lanes to fulfill the vision, goals, and objectives laid out by the Corridor Management Team.

HNTB evaluated three strategies to address these trends. **Strategy #1** requires all vehicles using the I-15 Express Lanes to have a transponder; **Strategy #2** raises the HOV requirement (for toll-free travel in the Express Lanes) to 3 or more occupants; and **Strategy #3** raises the maximum toll from its current level of $8 to $20.

The evaluated strategies are focused towards improving operations in the Express Lanes. HNTB's analysis has indicated that applying these strategies will improve peak-period travel times and increase reliability in the Express Lanes but may modestly impact conditions in the GP lanes. However, the analysis has demonstrated that the strategies would benefit the overall corridor by ensuring that all users have access to a congestion-free option when it is needed. As such, we have determined that the evaluated strategies support the CMT's vision, goals, and objectives.

Based on the findings of this operational analysis, HNTB recommends that SANDAG move forward with **Strategy #1 and #3**. There are three key reasons for this recommendation:

- All strategies support CMT's vision for the I-15 corridor which includes operating under regionally consistent business rules and complementing the GP lanes by providing a reliable and predicable commuting option.
- These strategies have been shown to be effective at improving travel times and reliability in the Express Lanes. It is important to note that when analyzed across all performance measures, **Strategy #1** consistently demonstrates the largest potential improvement.
- Taken together, **Strategies #1 and #3** will enhance fairness by improving enforcement and thereby reducing violators. Violators today have a threefold negative impact on the Express Lanes: (1) they consume capacity during peak periods, (2) they drive up the cost for customers that are abiding by the law, and (3) they deprive SANDAG of revenue that could be used to improve regional transportation services.

The next steps encompass four key activities, outlined below:

- **Next Step 1: Determination of Operational Strategies:**
    - ***Phase 1*:** The completion of this report marks the conclusion of Phase 1. It includes all activities necessary to determine which operational strategies best align with the I-15 vision, goals, and objectives and creating a Sketch Level Work Plan for the recommended operational strategies. As noted above, all 3 operational strategies considered as part of Phase 1 support the I-15 vision, goals, and objectives. HNTB's recommendation is to move forward with the two strategies—namely, **Strategy #1** and

Strategy #3—that have been shown to have the greatest operational impact while having the least impact on existing HOV customers.

- ***Phases 2 and 3*:** These two phases, as outlined in HNTB's Sketch Level Work Plan, address key tasks that will necessarily follow the completion of this operational analysis. As mentioned in the previous chapter, a key component of this implementation plan will be a social equity study. This study will identify potential disproportional impacts that the recommended operational strategies may cause to disadvantaged groups. This will result in a recommended public involvement and outreach plan to solicit meaningful input from all affected people. Its goal will be to identify appropriate mitigation strategies to ensure fair treatment is afforded to disadvantaged groups long after implementation. Any changes made to address operational issues will be made with appropriate consideration to social equity. A key outcome of Phases 2 and 3 will be whether to implement both **Strategy #1** and **Strategy #3** simultaneously, or whether they should be phased in separately.
- ***Phase 4*:** Based on the results of the social equity study, develop a detailed implementation plan that defines next steps to implement the preferred operational strategies. The detailed implementation plan will include a detailed schedule of activities, planned stakeholder coordination, a marketing and outreach strategy, mitigation strategies resulting from social equity study, a plan for roadway signage improvements, a technology and systems analysis and upgrade plan, a data collection and evaluation plan, an implementation cost estimate, and an operational readiness assessment.

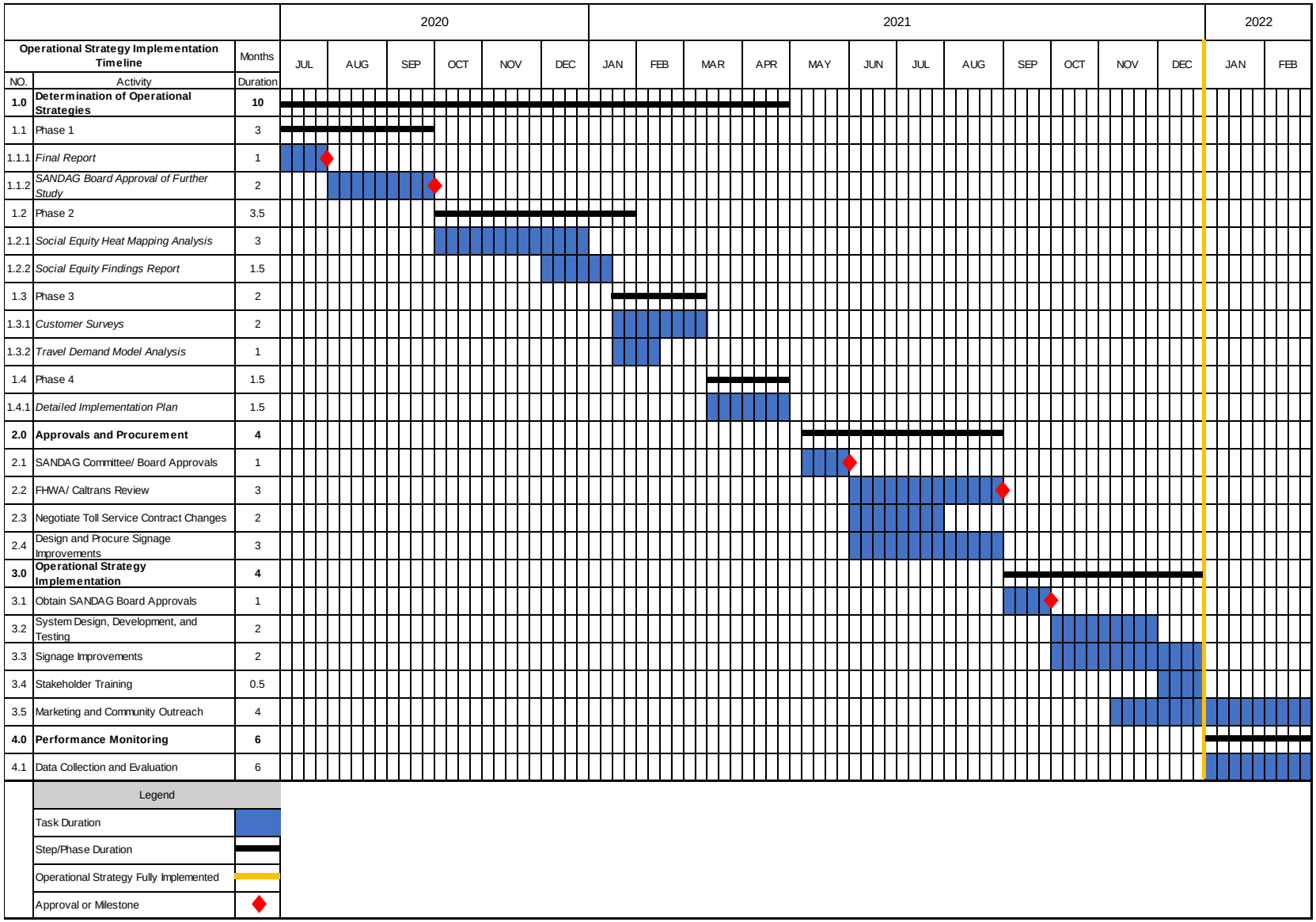
- **Next Step 2: Approvals and Procurement**: This activity includes seeking necessary stakeholder approvals and procuring implementation services.

- **Next Step 3: Operational Strategy Implementation**: This activity encompasses the necessary system and infrastructure updates to implement the operational strategies as well as stakeholder training and community outreach.

- **Next Step 4: Performance Monitoring**: Includes operational monitoring and evaluation of impacts to the defined I-15 performance measures. A key element of this activity will be to determine when it is appropriate to prepare **Strategy #2** for implementation. The analysis performed in Step 1 (and documented in this report) has already established that **Strategy #2** will be an effective tool for managing demand and advancing the vision, goals, and objectives for the corridor. The only question at this point is understanding the point at which it is best to implement it. We recommend SANDAG continually monitor Express Lanes performance and make data-based decisions regarding this strategy in coordination with Caltrans' planned HOV conversion guidelines.

The following high-level timeline presents the recommend next steps should CMT elect to implement any of the operational strategies evaluated in this study. A more detailed presentation of the Work Plan may be found in **Appendix H**, entitled *I-15 Express Lanes Operational Study Sketch Level Work Plan Technical Memorandum*.

Figure 6 – Sketch Level Work Plan



APPENDIX A: EXISTING OPERATIONAL ENVIRONMENT ASSESSMENT TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG
From: Will Allen, HNTB
Date: August 29, 2019
Subject: Existing Operational Environment Assessment Technical Memorandum

1. Purpose

The purpose of this memorandum is to provide an overview of the existing operational environment of the I-15 Express Lanes. The memo will review key operating characteristics of the facility and will summarize high-level trends in both traffic and revenue performance. The contents of this memo will be included in the Existing Operational and Performance Conditions Technical Memorandum to be delivered under Task 2.

The report will be structured in the following manner:

- 2 will provide an overview of the I-15 Express Lanes facility, reviewing its history and identifying how it is currently structured.
- 3 will discuss how the I-15 Express Lanes are operated today. This discussion will highlight some of the key business rules that currently govern operations on the facility.
- 4 will provide a high-level overview of the performance of the I-15 Express Lanes, with a brief discussion of key metrics related to traffic and revenue.

2. I-15 Express Lanes Overview

The I-15 Express Lanes operate 24/7 as a continuous 20-mile corridor, with State Route (SR) 78 marking the northernmost point and SR 163 the southernmost point. The subsections below provide a general overview of how the corridor is structured.

Number of Lanes

The I-15 Express Lanes provide 4 lanes of travel throughout the 20-mile length of the facility. The southern 16 miles of the facility are reversible. The lanes can be configured in one of three ways:

- 3 lanes SB / 1 lane NB
- 2 lanes SB / 2 lanes NB
- 1 lane SB / 3 lanes NB[1]

The northern 4 miles of the facility are fixed, providing 2 express lanes in each direction at all times.

[1] Although this configuration (1 SB / 3 NB) is physically possible to implement, it is **not** presently employed in practice. This will be discussed in the *Operating Approach* section.

Managed Lane Access

Drivers can access the express lanes in three primary ways:

- The primary means of access is from the general purpose (GP) lanes. In numerous sections of the roadway, drivers can shift directly from the GP lanes to the managed lanes.
- The corridor has three bus rapid transit centers (BRTCs)—one at Mira Mesa, one at Sabre Springs, and one at Rancho Bernardo—located directly adjacent to I-15. Each BRTC has a direct connection to the managed lanes.
- Some roadways (namely Hale Avenue, Del Lago Boulevard, and State Route 56) have direct access ramps, or DARs, connecting to the managed lanes.

For the southern 16 miles of the facility, the managed lanes are separated from the GP lanes by moveable concrete barrier. The separation changes to double-striped solid lines for the northern four miles.

History

The I-15 Express Lanes in their current form—20 miles, operating in both directions around-the-clock—were rolled out to the public in five phases. These phases are summarized below:

- **Phase 1:** The I-15 Express Lanes originally opened in 1988 as a high-occupancy vehicle (HOV) facility. The original facility—which was only eligible for use by vehicles with 2 or more occupants—was 8 miles long (the southernmost 8 miles of the existing corridor) and operated as two reversible lanes. The lanes were oriented southbound during the morning peak period and northbound during the evening peak period. This region of the facility is typically referred to as the "South Segment."
- **Phase 2:** In 1998, the South Segment converted to a "high-occupancy toll" (or HOT) facility, whereby single-occupant vehicles could use the facility for a fee. The fee was dynamically determined, based on the density observed in the express lanes. The toll system integrator (TSI) was TransCore—a role they have maintained through the present. The facility provided only one entry point and one exit point.
- **Phase 3:** In 2008/2009, a new 8-mile section (referred to as the "Middle Segment") was added immediately north of the original 8-mile section. The Middle Segment—continuing to operate as HOT lanes—was 4 lanes wide and provided service in both directions throughout the day. The Express Lanes were barrier-separated from the general purpose lanes. A moveable barrier in the middle of the Express Lanes (separating northbound and southbound traffic) enabled the corridor to operate with up to 3 lanes in one direction. The southern portion of the Middle Segment opened in September 2008, while the northern portion of the Middle Segment opened in March 2009.
- **Phase 4:** This phase was completed in 2011. The southernmost 8 miles (which had remained as a 2-lane reversible segment through the first three phases) was expanded by 2 lanes. Some additional access and egress points were added throughout the 8-mile section, and moveable barrier was installed to enable the facility to operate with up to 3 lanes in the peak direction.
- **Phase 5:** In January 2012, the northernmost 4 miles of the Express Lanes were completed, bringing the full length to 20 miles. This portion of the facility—typically referred to as the "North Segment"—

was separated by striping from the general purpose lanes. The median barrier was not moveable; therefore, the Express Lanes in this portion always operate with 2 lanes in each direction.[2]

3. Operational Overview

The day-to-day operation of the I-15 Express Lanes is guided by multiple regional entities and by business rules that have evolved over the 20+ year life of the facility. This section will highlight several of these elements.

Ownership & Operations

The I-15 Express Lanes corridor is owned and maintained by Caltrans, while its day-to-day operations are the responsibility of SANDAG. The corridor contains numerous technology systems that are owned and operated by different entities yet which function as a coordinated whole. Table 1 identifies some of the key systems within the corridor, and it summarizes the entity that is responsible for the operation of each system.

Table 1 – Technology Systems within the I-15 Express Lanes Corridor

Technology System	Operator
Barrier Transfer Machine	Caltrans
Toll Collection System	SANDAG / TransCore
Traffic Loop Detectors	Caltrans
Variable Toll Message Signs (VTMS)	SANDAG / TransCore
Changeable Message Signs (CMS)	Caltrans

Back Office Operations

At present, SANDAG's toll operations are supported by two back office systems. The I-15 Express Lanes are supported by TransCore, while SANDAG itself is providing the back office system for SR-125. In late 2019, SANDAG will be converting to a Regional Back Office System. The timing will roughly coincide with the transition to Kapsch as the Toll System Integrator for the I-15 Express Lanes. Kapsch will replace TransCore in lane 2019/early 2020.

Integrated Corridor Management System

The I-15 Express Lanes operate in the context of a complex transportation network, providing connections to heavily-traveled surface streets as well as to Bus Rapid Transit Centers (or BRTCs). To help facilitate efficient operations for the transportation system as a whole, SANDAG leads the operation of an Integrated Corridor Management (ICM) system. The stated purpose of the ICM system, which went live in 2013, is to allow the

[2] A graphical overview of the Southern, Middle, and Northern segments can be seen at https://www.sandag.org/uploads/publicationid/publicationid_6_1065.pdf (site accessed 08/06/2019).

various components of the transportation system in the vicinity of the I-15 Express Lanes to operate as a unified network. The system incorporates such components as:

- The coordination of arterial traffic signals, freeway ramp meters, and freeway traffic detectors to help facilitate the smooth flow of peak-period traffic.
- The provision of a coordinated detour messaging system to help direct motorists around major freeway incidents.[3]

The ICM system functions as a partnership with USDOT, Caltrans, regional transit service providers, and regional municipalities. SANDAG operates the system on a day-to-day basis as part of its regional ongoing ITS regional operations.

Traffic Detection

Also operating in the I-15 Express Lane corridor is the Caltrans ITS system. The system includes an extensive series of traffic detectors that capture traffic volumes at over 30 locations (in both directions) throughout the 20-mile corridor. These volumes—captured in each lane, encompassing both the general purpose lanes and the Express Lanes—are compiled by Caltrans as part of their Performance Measurement System (or PeMS). These data sources are not currently used by TransCore to help monitor real-time traffic conditions and adjust pricing. However, Kapsch is planning to incorporate data from the PeMS system when it assumes responsibility for operating the dynamic pricing system.

HOV Business Rules

Vehicles that have 2 or more occupants (also known as "high-occupancy vehicles" or "HOVs") can use the express lanes for free without needing a transponder. All single-occupant vehicles (or "SOVs") are responsible for paying the posted toll. The only exceptions are authorized Clean Air Vehicles (CAVs), which may be driven toll-free regardless of the number of occupants in the vehicle.

Transponder Rules

All SOVs must have a transponder to use the facility. The managed lane facility accepts any FasTrak transponder, including both Title 21 and 6C protocol compliant transponders.[4] In 2018, roughly 25-30% of all transponder transactions on the I-15 Express Lanes were recorded by transponders issued by SANDAG.[5]

[3] More information about the ICM System can be found here: https://www.sandag.org/index.asp?classid=13&projectid=429&fuseaction=projects.detail

[4] At present, 6C transponders are only read at the tolling locations at Miramar Way, Via Rancho Parkway, and the Sabre Springs Bus Rapid Transit Center.

[5] Information regarding how to acquire a FasTrak transponder for the I-15 Express Lanes can be found at https://511sd.com/fastrak511sd/I-15ExpLanes.

HOVs do not need to have a transponder to use the facility. However, if a vehicle sometimes operates as an SOV and sometimes as an HOV, then the driver may wish to acquire a switchable transponder.[6] These transponders have a switch that can toggle between SOV and HOV modes. When the vehicle has 2 or more occupants, the transponder may be switched to HOV mode and no toll will be assessed. Otherwise, the driver must switch the transponder to SOV mode and thereby incur a toll.

A very small subset of vehicles (e.g. California Highway Patrol vehicles, SANDAG maintenance vehicles) is authorized to use the I-15 Express Lanes without paying a toll; however, these vehicles are required to drive with a non-revenue transponder issued by SANDAG.

Enforcement

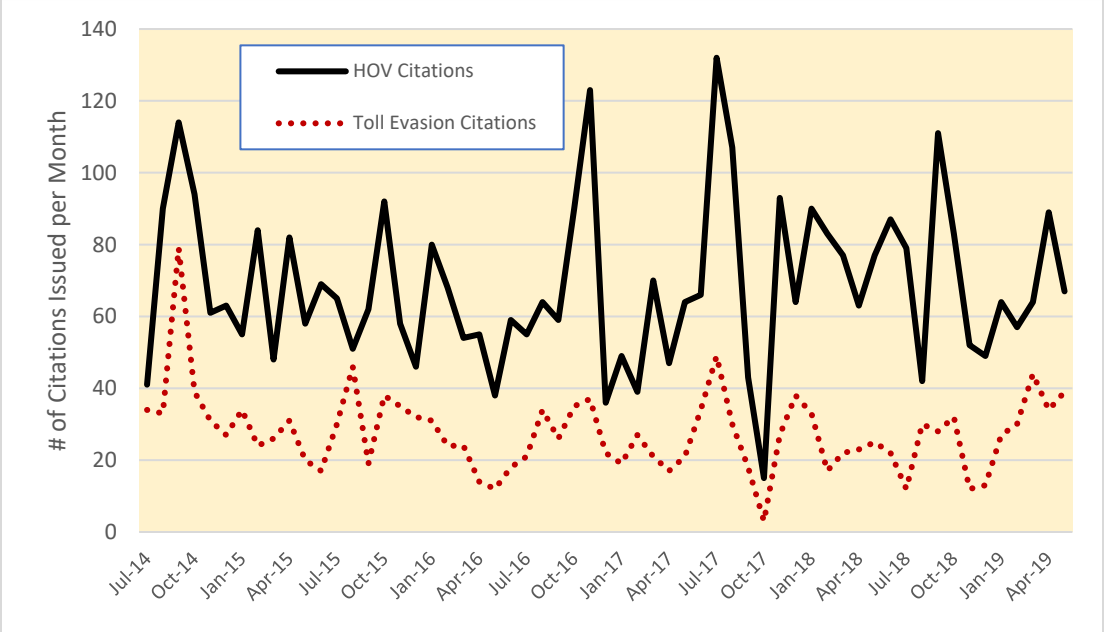
SOVs using the facility without a transponder can by fined if caught. Enforcement is performed visually by the California Highway Patrol (CHP). If an officer observes a vehicle in the Express Lanes that is not equipped with a transponder and has only one occupant, then the officer may pursue the driver and issue a citation.

Beacons are available at toll gantries to support the enforcement process. These beacons—visible to officers that are positioned just downstream of the toll point—indicate (a) whether a valid transponder was detected, and (b) whether the transponder (if detected) was in SOV or HOV mode. If no transponder is detected, or if the transponder indicates HOV mode, then an officer may visually inspect the vehicle as it passes by. If no passengers are observed, then the officer may the driver and issues a citation if appropriate. The effectiveness of these beacons is limited by the extent to which downstream areas are available for CHP officers to stop and observe traffic.

Figure 1 summarizes the number of HOV citations and toll evasion citations issued by CHP on the I-15 Express Lanes. The data, which records the number of citations issued on a monthly basis, extends back to the start of 2014.

[6] Switchable transponders are not currently available to customers establishing an account directly with I-15. However, switchable FasTrak transponders acquired from other agencies (such as LA Metro or the 91 Express Lanes) will work on the I-15 Express Lanes.

Figure 1 – I-15 Express Lanes Citation Summary

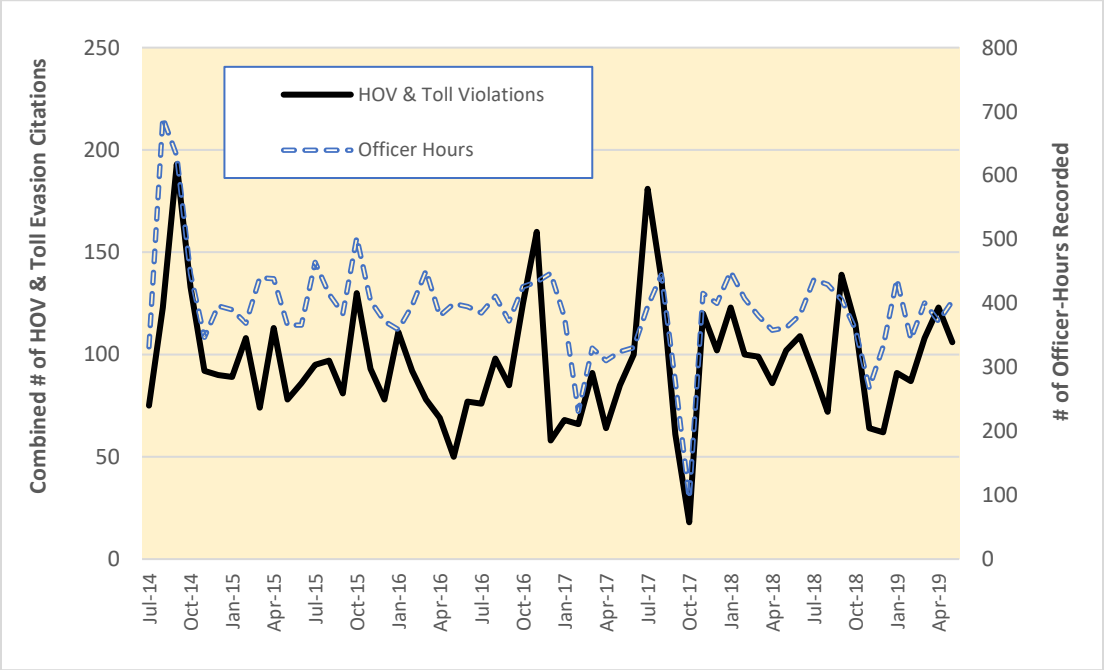


Two observations may be drawn from Figure 1:

- HOV citations have consistently been in the range of 60-80 per month.
- Toll evasion citations have consistently been in the range of 20-40 per month.
- Although the totals fluctuate from month to month, there has been no distinct trend in the number of citations issued over time.

Figure 2 shows how the total number of citations issued (both HOV and toll evasion) compares to the number of officer-hour recorded in a given month. The citations are reflected in the solid line and are read on the left vertical axis, while the officer-hours are reflected in the dashed line and are read on the right vertical axis.

Figure 2 – Comparison of HOV & Toll Violations with Officer Hours in the I-15 Express Lanes



One observation drawn from Figure 2 is that the number of citations tends to follow the number of officer-hours devoted to the Express Lanes. In months in which a relative surge in officer hours is recorded (e.g. August 2014, July 2017), one observes a spike in the number of citations issued. Conversely, periods of declining officer-hours are also marked by periods of declining citations (e.g. November 2016 to February 2017).

Pricing Approach

The current approach to pricing is handled by the TransCore system, in which the price to use the express lanes is based on the "density" of the express lanes (expressed in terms of vehicles per lane-mile). A dynamic pricing algorithm continually updates the density associated with each entry point to the express lanes. The density value that is calculated for each entry point is then referenced to a lookup table that generates a per-mile rate to be charged to all entering vehicles. The toll to be assessed is calculated as the per-mile rate multiplied by the length of the trip in the express lanes.

SANDAG's current business rules limit the per-mile rate to a maximum of $1, and they limit the per-trip maximum to $8. These rules have been in place since the Southern segment was convert to a reversible HOT lane in 1998. Neither the per-mile maximum nor the per-trip maximum were changed when the facility was expanded (as described in the **History** section).

In late 2019/early 2020, the TransCore system will be replaced by a Kapsch system. Kapsch will develop its own pricing algorithm, although it will still be subject to the business rules cited above. SANDAG has also made it clear to Kapsch that pricing under the new algorithm should be "consistent" with pricing that drivers have observed historically under the TransCore system.

The new pricing algorithm (currently under development) is being designed to provide added flexibility in congestion management while also helping to address existing issues, such as frequent premature conversions to HOV ONLY mode. Some changes that *may* be incorporated into the new pricing algorithm include the following:

- Revising the criteria for transitioning into HOV ONLY mode
- Drawing data from more locations, so that one aberrant data point doesn't have a disproportionate impact on rates and/or closures to SOVs
- Basing the price during any given interval not only on conditions in the preceding interval, but on congestion trends recorded during multiple preceding intervals.
- Considering the performance of the GP lanes in determining the appropriate fare in the Express Lanes.

Operating Approach

SANDAG strives to balance three general principles in managing usage of the express lanes:

- Keep the tolls low enough to encourage maximum usage of the express lanes
- Assess tolls that are sufficiently high to ensure a smooth and reliable ride in the express lanes
- Collect enough toll revenue to cover the cost of operating the facility

Occasionally, to preserve capacity for HOVs, SANDAG will temporarily prohibit SOVs from using the express lanes. There are two broad criteria for signing the express lanes as "HOV ONLY":

- The per-mile rate has reached the maximum value of $1
- The calculated density must be greater than or equal to 27 vehicles per lane-mile

If these two criteria are met for a given entry point, then this entry point is considered "congested" and it becomes "HOV ONLY." Moreover, SOVs will be prohibited from entering at all locations *upstream* of the congested entry point. Access continues to be restricted until the two criteria are both no longer satisfied.

To enforce the periods of restricted access, SANDAG has stated that any SOV entering the Express Lanes during "HOV ONLY" mode will be charged the $8 maximum trip fare **plus** an $8 penalty. In other words, if an SOV disregards the "HOV ONLY" sign at an entry point, he should be assessed a $16 charge, regardless of the length of the trip. However, SANDAG has had difficulty implementing this pricing approach, because they have been unable to implement the $8 penalty on vehicles whose FasTrak was issued by a different entity. In short: At present, the $8 penalty can only be assessed to tags issued by SANDAG. This limits the ability of SANDAG to manage the Express Lanes during congested periods.

Southbound usage of the express lanes is heaviest during the AM peak. Therefore, on Mondays through Thursdays, during the AM peak period, the Middle and Southern segments are reconfigured such that the entire 16-mile length operates with 3 express lanes. This leaves only 1 express lane operating northbound.

During all other times of the day in the "reversible" portion of the facility, the lanes are configured to provide 2 express lanes in each direction.

4. Performance Summary

The purpose of this section is to provide a general overview of the usage of the I-15 Express Lanes, both in terms of the volume of traffic served and in terms of the amount of revenue generated.

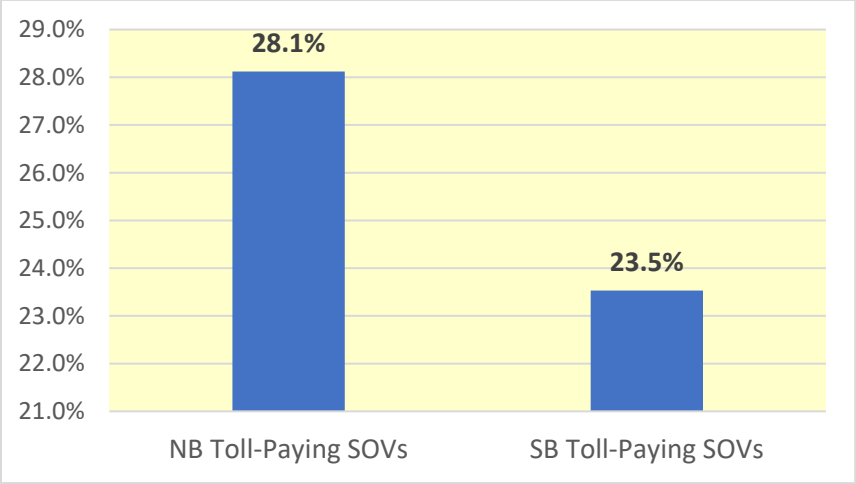
Traffic Overview

The following high-level traffic summary is provided to put the operating environment into the appropriate context. Comprehensive analysis of the operating conditions and performance will be included in the Existing Operational and Performance Conditions Technical Memorandum to be delivered under Task 2.

Over the 12-month period from June 2018 through May 2019, the express lanes served approximately 68,500 trips per day. On average, usage of the express lanes in the SB direction (38,500 trips per day) was slightly higher that usage in the NB direction (29,900 trips per day). The higher southbound volume helps explain why the lanes are configured to provide an extra SB lane during the AM peak period.

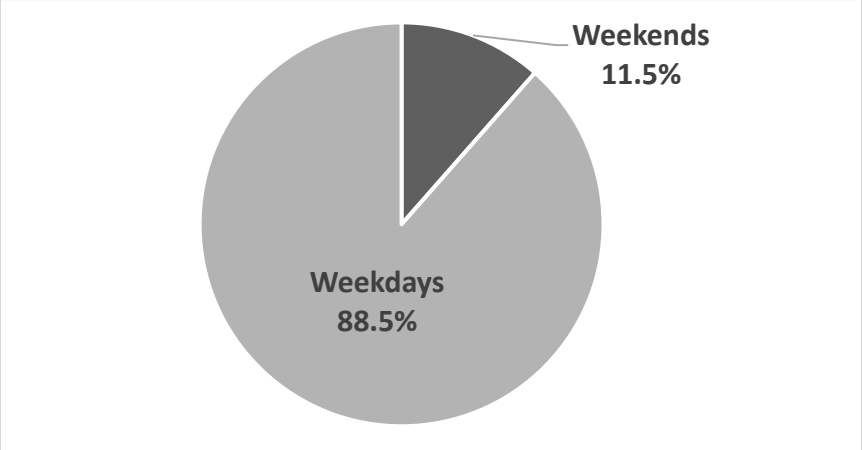
Only about one in four express lane trips are made by toll-paying SOVs. The chart below illustrates how SOV usage varies by direction.

Figure 3 – Percentage of Toll-Paying SOVs by Direction, Jun'18 thru May'19



As Figure 3 illustrates, the northbound express lanes have a higher market share of toll-paying SOVs than SB traffic. However, the overall volume of SB traffic is nearly 30% higher than NB. As a result, the actual daily volume of toll-paying SOVs is slightly higher in the SB direction (average of 9100 SB vs. 8400 NB per day). Toll-paying SOV trips are much common on weekdays compared to weekends. Figure 4 illustrates how SOV trips are distributed throughout the week.

Figure 4 – Distribution of SOV Trips by Type of Day

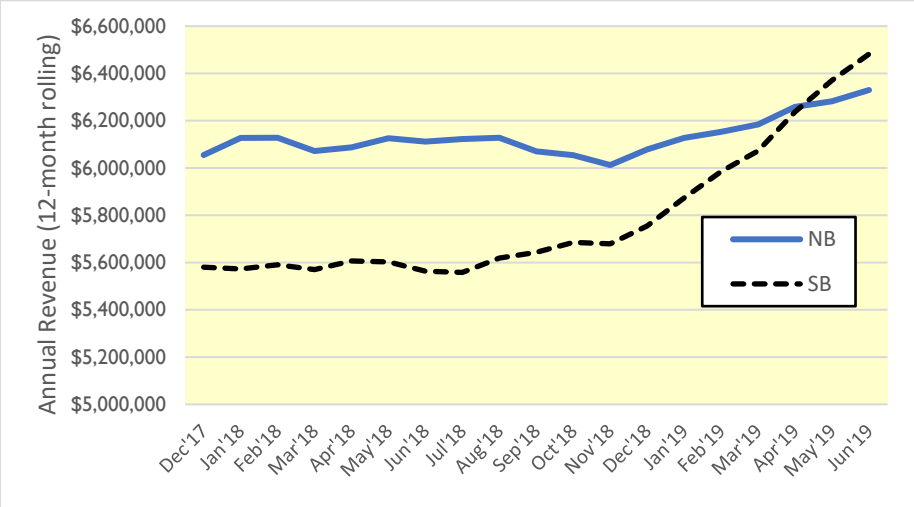


As Figure 4 illustrates, weekdays produce nearly 90% of all toll-paying SOV trips. Even though weekends account for 29% of the days in a year, they account for less than 12% of the toll-paying vehicles in the I-15 Express Lanes.

5. Revenue Overview

Over the 12-month period from July 2018 through June 2019, SANDAG collected **$12.8 million** in toll revenue from the I-15 Express Lanes. Figure 5 illustrates how revenue has grown over the past 18 months. The chart depicts a rolling 12-month revenue total for the I-15 Express Lanes. The data is broken out by direction.

Figure 5 – Annual Revenue, 12-Month Rolling Total, Dec'17 through Jun'19

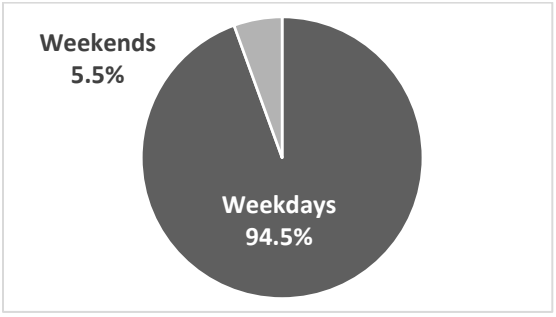


The following observations may be drawn from Figure 5:

- From December 2017 through August 2018, the rolling 12-month revenue total (both directions combined) was consistently in the range of $11.6 to $11.7 million. Northbound revenue (averaging about $6.1 million) was consistently higher than southbound revenue (averaging just under $5.6 million).
- Since August 2018, southbound revenue has steadily climbed. In the most recent 12-month period (July 2018 through June 2019), southbound revenue totaled just under $6.5 million.
- Although northbound revenue has grown slightly in recent months, southbound revenue is now slightly outpacing northbound revenue.

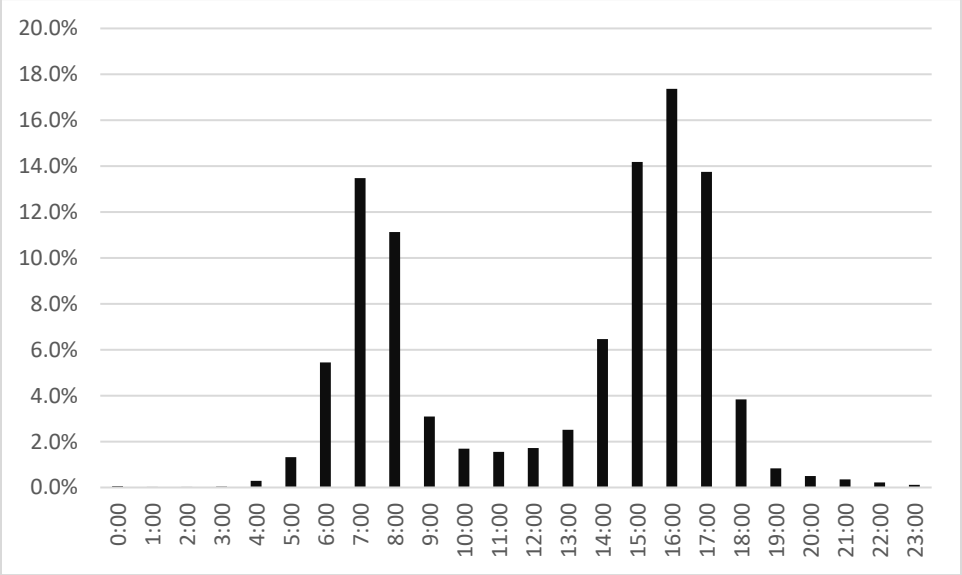
Figure 6 illustrates the relative extent to which weekdays vs. weekends contribute to gross revenue in the I-15 Express Lanes.

Figure 6 – Distribution of Revenue by Day of the Week



As Figure 6 illustrates, weekdays account for nearly 95% of all revenue collected from the I-15 Express Lanes. This result stems from the combination of two factors: (1) weekday volumes of toll-paying SOV vehicles are much higher than weekend volumes; and (2) weekdays average tolls are higher than weekend average tolls. The collection of revenue tends to be concentrated during peak periods. This is illustrated by Figure 7, which shows how express lane revenue varies by hour of the day.

Figure 7 – Distribution of Revenue by Hour



A close look at the data indicates that over two-thirds of the toll revenue is collected during the five busiest hours (7am-9am and 3pm-6pm) on weekdays (Monday thru Friday).

APPENDIX B: I-15 EXPRESS LANES CORRIDOR MANAGEMENT TEAM VISION TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, HNTB

Date: August 29, 2019

Subject: I-15 Express Lanes Corridor Management Team Vision Technical Memorandum

Purpose

The purpose of this memorandum is to document the I-15 Express lanes Corridor Management Team's (CMT) vision for I-15 Express Lanes. The memo will summarize the outcomes of the CMT Visioneering Workshop held on June 28, 2019, including the CMT's vision, objectives, and goals for the facility. The contents of this memo will be included in the Existing Operational and Performance Conditions Technical Memorandum to be delivered under Task 2.

Background

There are countless ways to study the operations of a transportation corridor. In order to focus this study's evaluation criteria (performance measures) on what is truly of importance to the CMT, it is critical to define a vision, goals, and objectives.

- A *vision* is sometimes referred to as "the big picture" or "the dream". The vision for the I-15 Express Lanes should broadly describe the ideal operating conditions for the corridor.
- Once the vision has been defined, specific *goals* are developed that are focused on the vision. Goals are typically general statements that describe the milestones we want to achieve in support of the vision.
- An *objective* translates the goals' general statements into quantifiable measurable results. Ultimately, the performance measures selected for this study will be closely tied to the I-15 Express Lanes objectives.

I-15 Express Lanes Vision

In early 2019, the I-15 Express Lanes CMT developed a vision, goals, and objective for the I-15 corridor to be used as the foundation for the planned tasks and activities to be carried out in 2019 by the CMT. HNTB conducted a workshop with the I-15 Express Lanes CMT on June 28, 2019 to better understand and document the CMT's vision for the I-15 Express Lanes. Based on input received from the meeting participants (Attachment 1) and the CMT Vision previously established in early 2019 (Attachment 2), the following vision statement has been drafted for use in guiding the project.

I-15 Express Lanes Vision Statement

Provide a world class transportation facility that:

- Provides safe, reliable, predictable commute for I-15 Express Lanes customers;
- Provides easy to use travel options without barriers that meets the needs of today while also sustaining future growth and evolution in travel options;
- Has regionally consistent business rules and operating policies;

- Is aligned with Caltrans' & SANDAG's Mission and Vision;
- Strengthens successful partnerships with SANDAG, Caltrans, MTS and other stakeholders;
- Is a model for other Express Lanes corridors in the region; and
- Complements I-15 General Purpose Lane operations.

I-15 Express Lanes Goals & Objectives

The I-15 Express Lanes Vision will be supported by several goals and objectives which will be monitored by several performance metrics. Based on input collected during the CMT Visioneering Workshop held on June 28, 2019, the following goals and objectives have been drafted for use in guiding the project. These goals and objectives will be monitored by several performance measures to be defined in *I-15 Express Lanes Operational Study Performance Measures Technical Memorandum* and serve as the foundation for evaluating operational strategies for the I-15 Express Lanes.

Goals

- Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls.
- Generate sufficient revenue to sustain I-15 Express Lanes operations.
- Inform public of travel options, including SOV, HOV, and transit, and provide knowledge for customers to use making travel choices.
- Provide equal access to all customers.
- Equally enforce the toll policy across all travel choices.
- Minimize maintenance and operations costs.
- Enhance corridor management and operations.

Objectives

- Optimize and maintain I-15 Express Lane trip reliability.
- Reduce I-15 corridor (GP and EL) person and/or vehicle delay.
- Improve I-15 corridor (GP and EL) person and/or vehicle throughput.
- Improve efficiency in the Express Lanes.
- Improve transit service performance.
- Reduce incidents and associated travel delays.

Based on the I-15 Vision Statement and these Goals and Objectives (and starting with the performance measures identified in the I-15 Express Lanes CMT Charter, a comprehensive list of performance measures will be proposed for the Project (to be identified in the forthcoming I-15 Express Lanes Operational Study Performance Measures Technical Memorandum). It is anticipated that at least one performance measure will be associated to each of the I-15 Express Lanes Goals and Objectives listed herein.

Attachment 1: CMT Vision Workshop Participants

Ryan Ross - SANDAG
Alex Estella - SANDAG
Peter Thompson - SANDAG
Francine Jimenez - SANDAG
Gerard Chadergian - Caltrans
Erwin Gojuangco - Caltrans
Shahin Sepassi - Caltrans
Mario Oso - Caltrans
Allan Kosup - Caltrans
Rajpreet Singh - Caltrans
Brian Pecus - Caltrans
Gustavo Dallardo - Caltrans
Marcelo Peinado - Caltrans
Greg Hulsizer - HNTB
Will Allen - HNTB

Attachment 2: 2019 I-15 Corridor Management Team (CMT) Work Plan

2019 I-15 Corridor Management Team (CMT) Work Plan

The following document serves as a roadmap for proposed tasks and activities to be carried out in 2019 by the CMT. The document provides a background of the CMT, review of work efforts carried out by the CMT, and identifies a list of key activities that support on-going operations and management of the I-15 corridor.

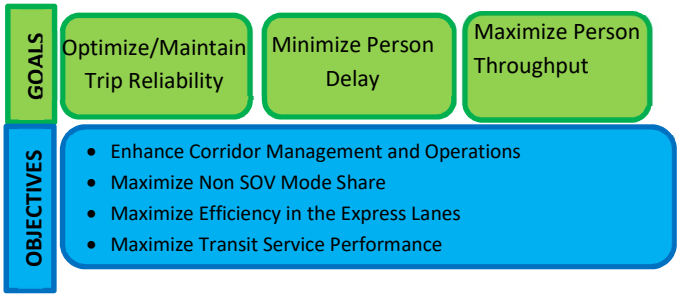
CMT TEAM BACKGROUND

The California Department of Transportation (Caltrans) District 11, the San Diego of Association of Governments (SANDAG), and the San Diego Metropolitan Transit System (MTS) have established the I-15 CMT. The establishment of the CMT is formalized through the development of the I-15 CMT Charter executed by SANDAG, Caltrans District 11, and MTS in October 2016. The following principles served as the motivating factors for the establishment of the CMT and also served as the foundation for establishing the CMT Vision, Goals, and Objectives.

1. A need for corridor wide and multi-agency cooperation to coordinate day to day system management and operations.
2. A need to improve procedural business practices to establish common and agreed upon performance measures and a performance based corridor management assessment process through the establishment of consistent data collection, analyses, and reporting procedures.
3. A need to improve cross agency consultation and coordination of corridor marketing and public information activities to better communicate the value and benefits of operational strategies and improve understanding of available modes and transportation choices along the I-15 corridor.

CMT Vision

Establish and carry out a multi-modal transportation platform that promotes and fosters transportation system/modal efficiencies to improve the flow of people and goods in an effort to manage congestion. The team will place emphasis on corridor performance management to optimize overall corridor operations and to identify and implement multi-modal transportation strategies.



CMT Meeting Frequency

CMT meetings are held on a monthly basis with quarterly meetings reserved for setting guidance and recommendations. Discussions by the CMT focus on topics associated performance management and reporting process, assessing and identification of possible operational strategies, and coordination of public information and communications activities as necessary. CMT monthly meetings generally included participation from key CMT technical level staff and team leads from each agency. CMT recommendations, request for guidance, and strategic level of discussions are carried out on a quarterly basis. These meetings include the participation of executive/director level CMT management staff.

BAKGROUND WORK EFFORTS

Since 2015 the CMT focused on establishing the institutional structure, initial data collection and baselining activities, and reviewing baseline performance findings for recommending a regularly-scheduled movable barrier operations and Express Lane configuration that would best support CMT established goals. These efforts are highlight below:

1. Establishment of I-15 CMT Charter (2016) - The I-15 CMT Charter was executed by all partner agencies on October 2016. The I-15 CMT Charter is intended to serve as a roadmap to help guide and promote multi-agency commitment and communications for on-going and day to day corridor operations and management. The development and execution of the CMT Charter reflects a paradigm shift from traditional management and operational practices and it is the first Charter of its kind in the State of California.
2. Initial Baseline Performance Assessment (2015-2016)- Completion of data collection and a baseline performance assessment for the I-15 corridor. These efforts were initiated in 2015 and have served as the basis for the CMT's recommendation to extend the Express Lanes configuration. Through this effort, the CMT gained a historical understanding of performance changes, benefits, and impacts for moving the barrier on Thursdays during morning and afternoon peak periods. Key findings through this effort also have served as the platform for establishing an ongoing, fact-based performance reporting process for benchmarking, tracking, monitoring, and documenting the benefits and impacts that may result with the implementation of future operational strategies.
3. CMT Highlights Completed Tasks (2016 – 2018):
    a) November 2016 – The CMT recommended and implemented the discontinuation of the Thursday afternoon northbound movable barrier operations shift from 3NB+1SB to a 2NB+2SB configuration. The discontinuation was implemented the week of November 14, 2016 to reduce delays and improve trip reliability in both the northbound and southbound directions.
    b) February 2017 – Based on the performance assessment, the CMT discerned the impacts and benefits under a 3+1 Express Lanes operation and such efforts served as the basis for recommending the extension of 3SB+1NB Express Lanes configuration to Monday, Tuesday, and Wednesday mornings. The recommendation was implemented on February 13, 2017. Leading up to the recommendation implementation date, the CMT team worked with public information and marking and communications staff. This effort included the

preparation of public outreach material and outreach activities used to inform the public of the movable barrier system change.

c) December 2017-January 2018 - The CMT recommended and established a 2018 Holiday schedule that maintained the movable barrier operations to a 2NB+2SB configuration. The recommendation was based on a performance assessment that benchmarked traffic demand use on the Express Lanes for a typical weekday versus a scheduled holiday weekday which generally noted significant lower demands during scheduled holiday weekdays.

d) July – September 2018 Express Lanes Pavement Restriping – The CMT discussed and vetted proposed restriping changes for the Express Lanes facility along the northern section of the corridor; north of the Felicita IAP for the SB direction and north of the Centre City IAP in the NB direction. Proposed recommendations set by the CMT where implemented in mid- September, 2018 by Caltrans as part of their I-15 corridor Express Lanes restriping contract.

2019 CMT WORKPLAN

The 2019 CMT Workplan focuses on carrying out 4 key activities through December 2019.

1. **CMT performance assessment, reporting, and recommendations**

The CMT will continue to collect, assess, and document and report on the performance benefits and impacts of the I-15 corridor on a monthly and quarterly basis. CMT activities will include:

a) Assess and report on performance findings that reflect the extension of the 3SB+1NB Express Lanes configuration for Monday, Tuesday, and Wednesday, and Thursday morning conditions – On-going

b) Work with transit team to identify and determine available transit data metrics and data collection procedures to be applied to support on-going CMT reporting activities – Quarter 1 2019

c) Overall performance assessment process will be documented via the completion of a CMT Decision Process and Procedural Guidelines – Q2 2019

d) CMT will work with Caltrans staff to enhance performance reporting process based on newly established data collection efforts including consideration of additional metrics and improvements on quarterly performance reporting – On-going

2. **CMT Operational Improvement Discussion and other Coordination Activities (On-going)**

a) CMT on an on-going basis will examine possible solutions that may include assessing known operational issues along key corridor weaving, access points, and bottleneck locations

b) CMT will serve as key stakeholder for reviewing and providing input and support the completion of the I-15 Express Lanes Operational Study. The study is expected to get underway in February/March 2019

c) CMT will monitor, track, and provide status updates on maintenance/repairs/enhancements to field data collection systems in an effort to minimize gaps in CMT on-going data collection and performance assessment

d) Coordinate and work with PIO/MarComm team to support CMT activities as necessary to promote a common and collaborative CMT public information platform

e) Reach out and have CHP participate during CMT meetings as necessary

3. **CMT to serve as key stakeholder during the development and implementation of planned and future I-15 Projects/Studies (2019 – beyond)**

   a) I-15 Express Lanes Operational Study

   b) New I-15 Tolling Roadway System Improvement and Regional Back Office Tolling System Project

4. **CMT Discussions on Strategic Research/Initiatives via Tolling Consultant to support CMT Activities (2019 – beyond)**

   a) Coordinate efforts with CT and SANDAG to support Big Data Analytics Implementation Strategy to Support CMT activities

   b) Provide support for advancing AV Proving Grounds work plan

   c) Monitor possible funding/legislative activities and opportunities that support CMT efforts and engage CMT to identify potential action items as necessary

APPENDIX C: I-15 EXPRESS LANES OPERATIONAL STUDY PERFORMANCE MEASURES TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, Todd Pendleton, Amit Thomas, HNTB

Date: October 28, 2019

Subject: I-15 Express Lanes Operational Study Performance Measures Technical Memorandum

Purpose

The purpose of this memorandum is to develop a list of recommended performance measures for the I-15 Express Lanes Operational Study and future corridor monitoring. The memo will summarize the various performance measures that will be evaluated for the facility and the overall corridor. In addition to a detailed listing of the various performance measures, the data source and method of estimation is also presented.

In presenting a list of performance measures, this deliverable will help provide a foundation for monitoring the effectiveness of the existing I-15 Express Lanes in achieving the goals and objectives established by the Corridor Management Team (CMT). Moreover, these measures can serve as a basis for assessing the extent to which any proposed recommendations (to be presented in Task 3) help improve the performance of the Express Lanes.

The contents of this memo will be included in the Existing Operational and Performance Conditions Technical Memorandum to be delivered under Task 2.

Background

HNTB recently conducted a workshop with the I-15 Express Lanes CMT on June 28, 2019 to document the CMT's vision for the I-15 Express Lanes. Based on the I-15 Vision Statement and the Goals and Objectives (including the performance measures identified in the I-15 Express Lanes CMT Charter) developed as an outcome from the Visioneering workshop, a comprehensive list of performance measures are proposed for the Project. The I-15 Express Lanes goals and objectives will be monitored by several performance metrics that are described in this memorandum.

Data Sources

Data from several different sources were extracted and processed for developing various performance measures. Broadly, the data sources fall under the following categories:

1. Account Management System (AMS) for the I-15 Express Lanes: This portal (provided by TransCore) will be used to extract various data elements related to the I-15 EL tolling system including (but not limited to) the following:
    - hourly traffic volumes at key EL mainline tolling locations
    - point to point traffic from entry to exit points on the EL system
    - HOV-transponder/SOV-transponder/other users percentage shares
    - vehicle miles of travel (VMT) estimates
    - vehicle hours of travel (VHT) estimates

2. Caltrans Performance Measurement System (PeMS) System: The traffic data displayed on the map is collected in real-time from several individual detectors. These sensors span the I-15 corridor (General Purpose Lanes and Express Lanes) across the study area. Since the I-15 corridor has sections which have moveable barriers, the PeMS system does not accurately depict the parameters such as traffic volumes, speeds, travel times, and delays within the Express Lanes (EL); however, this data is available for the General Purpose (GP) lanes.
3. National Performance Management Research Data Set (NPMRDS) Speed and travel time data: This dataset, which is powered by INRIX®, provides detailed travel time and speed data for the GP and EL.
4. Transit data report (from SANDAG, MTS): Pending availability. This data set, if available, will likely include transit ridership in the corridor, transit on-time performance and transit peak load factors.
5. Violation data: This data set, provided by SANDAG staff, includes summaries of the violation rates at a few key locations along the I-15 Express Lanes.

I-15 Express Lanes Performance Measures

The evaluation of existing conditions for the I-15 corridor – both GP Lanes and EL – will be monitored by several performance metrics that were developed from the June 2019 Visioneering workshop conducted as part of the I-15 EL Operational study. The table on the following page provides a summary of how each of the I-15 objectives can be monitored by various performance measures.

	Goals and Objectives	Related Performance Measures	Data Sources	Additional Sources
Goals	Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls	· % of EL vehicles traveling as SOVs	SANDAG - Vehicle Occupancy Surveys	
		· % of EL vehicles carrying 2 people (HOV2)	SANDAG - Vehicle Occupancy Surveys	
		· % of EL people traveling as HOV3+	SANDAG - Vehicle Occupancy Surveys	
		· Transit ridership	SANDAG	
	Generate sufficient revenue to sustain I-15 Express Lanes operations	· Express Lanes Revenue	SANDAG	
		· Estimated Express Lanes Operating Costs	SANDAG	
		· Estimated Net Revenue (revenue less operating costs)	SANDAG	
	Minimize O&M costs	· Annual average cost incurred per trip served	SANDAG	
Objectives	Optimize and maintain I-15 Express Lane trip reliability	· EL Travel Times (daily and peak period)	NPMRDS (powered by INRIX®)	
		· EL Speeds	NPMRDS (powered by INRIX®)	
		· EL 90th percentile travel times	NPMRDS (powered by INRIX®)	
		· Frequency & Duration of HOV ONLY events	SANDAG	
	Reduce I-15 corridor (GP and EL) person and/or vehicle delay	· EL vehicle-hours of travel (VHT)	AMS - Traffic By Location Details [VOLUMES]	NPMRDS (powered by INRIX®) [SPEEDS]
		· EL vehicle-hours of delay (VHD)	AMS - Traffic By Location Details [VOLUMES]	NPMRDS (powered by INRIX®) [SPEEDS]
		· GP Travel Times (daily and peak period)	NPMRDS (powered by INRIX®)	
		· GP Speeds	NPMRDS (powered by INRIX®)	
		· GP VHT	PeMS	
		· GP VHD	PeMS	
	Improve I-15 corridor (GP and EL) person and/or vehicle throughput	· EL vehicle throughput	AMS - Traffic By Location Details	
		· EL VMT	AMS - Traffic By Location Details [VOLUMES]	NPMRDS (powered by INRIX®) [SPEEDS]
		· EL person-miles traveled	AMS - Traffic By Location Details [VOLUMES]	NPMRDS (powered by INRIX®) [SPEEDS] SANDAG SURVEYS [OCCUPANCY]
		· GP vehicle throughput	PeMS	
		· GP VMT	PeMS	
		· # of FasTrak transponders and active accounts	AMS - Daily Accounts Summary	
	Improve efficiency in the Express Lanes	· EL person throughput	AMS - Traffic By Location Details [VOLUMES]	SANDAG
		· Average FasTrak user trip length	AMS - Point to Point Revenue Traffic	
		· Express Lanes violation rates	SANDAG violation survey	
		· Frequency of HOV-Only Mode	SANDAG	
	Improve transit service performance	· Transit on-time performance	N/A	
		· Transit peak load factor	SANDAG	
	Reduce incidents and travel delays	· Number of travel incidents per year from CHP	PeMS	

In this section, a brief description of each key performance measure, its data source and method of calculation (if computed or estimated) is provided.

EL Vehicle and Person Throughput: This includes traffic volumes and person trips by time of day for average weekdays at key EL mainline locations where vehicles using the express lanes are detected and monitored. Source: AMS

GP Vehicle Throughput: This includes traffic volumes by time of day for average weekdays at various GP mainline locations throughout the corridor, summarized from various detectors along the GP lanes. Note, vehicle occupancy data for GP traffic is not available so GP Person Throughput cannot be evaluated.
Source: PeMS

EL Speeds, EL Travel Times and 90th Percentile Travel Time: This includes travel time and median speed data for various EL segments throughout the corridor summarized by time of day for an average weekday. The 90th percentile travel time will include weekday peak travel times where the travel time experienced by 90 percent of motorists was equal to or faster than the reported time.
Source: INRIX (extracted via the NPMRDS portal)

Frequency and Duration of HOV ONLY events: The *frequency* of HOV ONLY events identifies the average number of times per month in which some portion of the I-15 Express Lanes is restricted to HOVs. The *duration* of HOV ONLY events identifies the average length of time (in minutes) for which a portion of the I-15 Express Lanes is restricted to HOVs. These performance measures will be broken out by direction.

Source: AMS

GP Speeds and Travel Time: This includes speed data for various GP segments throughout the corridor, summarized by time of day for an average weekday. Additionally, travel times to traverse the entire corridor will be estimated by combining the various GP mainline segments.
Source: Speed data from INRIX (extracted via the NPMRDS portal)

EL VMT/VHT/VHD and person-miles traveled: These measures provide an estimate of the total vehicle miles of travel (VMT), vehicle hours of travel (VHT) and vehicle hours of delay (VHD) by combining the AMS traffic volume data, the travel time from INRIX, and distance for various segments of the I-15 EL during the peak periods. Additionally, the person miles-traveled and person delay will be estimated for the Express Lanes during peak periods.

Daily VMT represents the total miles driven by vehicles within the I-15 corridor on a daily basis. This value for the I-15 Express Lanes can be calculated in the following manner, with the value *n* representing the number of logical segments in the corridor:

$$VMT(daily)_{EL} = \sum_{n}^{1} V_1 * L_1 + V_2 * L_2 + \cdots + V_n * L_n$$

Where

- V_n = Average annual daily traffic for logical segment *n* within the I-15 Express Lanes
- L_n = Length of logical segment *n*, in miles

Daily VHT in the I-15 Express Lanes is calculated in a similar manner. This is illustrated by the equation below:

$$VHT(daily)_{EL} = \sum_{n}^{1} V_1 * TT_1 + V_2 * TT_2 + \cdots + V_n * TT_n$$

Where

- V_n = Average annual daily traffic for logical segment *n* within the I-15 Express Lanes
- TT_n = Average travel time experienced by the vehicles in the I-15 Express Lanes on logical segment *n* on an average day, in hours

Finally, VHD in the I-15 Express Lanes may be calculated in the following manner:

$$VHD(daily)_{EL} = \sum_{n}^{1} V_1 * D_1 + V_2 * D_2 + \cdots + V_n * D_n$$

Where

- V_n = Average annual daily traffic for logical segment *n*
- D_n = Average delay experienced by the I-15 Express Lane vehicles on logical segment *n* on an average day, in hours. A "delay" is defined as the difference between the estimated travel time and the travel time if the observed speed was 60 mph.

Source: Volumes from AMS, speed data from INRIX

GP Lanes VMT/VHT/VHD: These measures provide the same information as the measures cited above, except that they focus on vehicles traveling on the General Purpose (GP) Lanes. The supporting calculations combine the PeMS traffic volume data, the travel time from INRIX, and distance for various segments of the I-15 GP. In other words, the formulas cited above are the same, but the sources of the underlying data are different.

Source: Volumes from PeMS, speed data from INRIX

Number of FasTrak Transponders: The number of transponders can be estimated using data from TransCore.

Source: AMS System

Number of FasTrak Accounts: The total number of accounts can be estimated based on data from TransCore.

Source: AMS System

Average FasTrak User Trip Length: The average trip length on the EL can be estimated using Distance data (each entry-exit point) paired with traffic composition data (SOV, HOV, etc.).

Source: AMS System (EntryExitDistance)

Express Lanes Revenue: Average daily or monthly revenue estimates for EL estimated by aggregating the revenue for each origin-destination pair (entry-exit points to the EL)

Source: AMS System (PointToPointRevenueTraffic)

Estimated Express Lanes Operating Costs: Average daily or monthly cost to operate the toll collection system and barrier transfer machine.

Source: SANDAG Toll System Vendor contract and SANDAG/Caltrans barrier transfer machine budget

Estimated Net Revenue (revenue less operating costs): Average daily or monthly net revenue, calculated as Express Lanes Revenue less Express Lanes Operating Costs.

Average Cost Incurred Per Trip Served: Average daily or monthly cost, calculated as the operating costs divided by the trips served during the analysis period.

Percent of EL Vehicles Traveling as SOVs: This represents the share of EL vehicles that are SOV vehicles.

Source: Average Vehicle Occupancy (AVO) data from SANDAG

Percent of EL Vehicles carrying 2 people: This represents the share of EL vehicles that carry 2 people.

Source: Average Vehicle Occupancy (AVO) data from SANDAG

Percent of EL Vehicles Traveling as HOV3+: This is the share of EL vehicles that carry 3 or more people.

Source: Average Vehicle Occupancy (AVO) data from SANDAG

Percent of EL people traveling in HOVs: The percent of EL people traveling in HOVs can be estimated by applying the share of SOVs, HOV2 and HOV3+ vehicles and the appropriate occupancy factor to each of the vehicle occupancy categories of the EL vehicles defined above (i.e., the percent of EL vehicles traveling as SOVs, percent of EL vehicles carrying 2 people, percent of EL vehicles traveling as HOV3+).

Source: Average Vehicle Occupancy (AVO) data from SANDAG

Express Lanes Violation Rates: Violation rates during peak periods shown as a percentage of total transactions based on summaries provided by SANDAG at key locations along the I-15 Express Lanes.

Source: SANDAG

Number of travel incidents per year from CHP: Annual travel incidents on the I-15 corridor from historical PeMS data

Source: PeMS

Other transit-related performance measures that can be summarized include:

Transit Ridership: Bus ridership (by route and time period) for MTS routes using the I-15 corridor

Transit On-Time Performance: Percentage of passenger drop-offs that occur on-schedule

Transit Peak Load Factor: Percentage of seat-miles that are occupied by passengers during peak periods

Source: MTS (provided to HNTB via SANDAG)

APPENDIX D: EXISTING OPERATIONAL PERFORMANCE ANALYSIS TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, Todd Pendleton, Amit Thomas, HNTB

Date: October 21, 2019

Subject: Existing Operational Performance Analysis Technical Memorandum

1. Purpose

The purpose of this memorandum is to summarize the existing operational performance analysis of the I-15 Express Lanes corridor. The memo will review key operating characteristics of the facility and will summarize high-level trends of various performance measures including (but not limited to) throughput, speeds, travel times, high-occupancy traffic served, FasTrak transponder usage, traffic and revenue performance. This memo will help SANDAG further evaluate the existing traffic operations on the I-15 Express Lanes (EL) and General Purpose (GP) lanes.

This technical memo does not provide detailed explanations for the operational trends identified within this memo. However, further analysis of these trends will be included in the *Existing Operational and Performance Conditions Technical Memorandum* to be delivered under Task 2.

2. Project Background and Operating Characteristics

The I-15 ELs operate 24/7 as a continuous 20-mile corridor, with State Route (SR) 78 marking the northernmost point and SR 163 the southernmost. The *Existing Operational Environment Assessment Technical Memorandum* provides an overview of the existing operational environment of the I-15 corridor.

The sections below provide a general overview of the I-15 corridor operating characteristics. The I-15 ELs provide 4 lanes of travel throughout the 20-mile length of the facility. The southern 16-mile section has a moveable barrier, by which the ELs are typically configured in one of two ways: 3 lanes SB / 1 lane NB or 2 lanes SB / 2 lanes NB. The northern 4 miles of the facility (typically referred to as the "Northern Segment") are fixed, providing 2 ELs in each direction at all times. For the southern 16 miles of the facility (comprised of the "Middle Segment" and "Southern Segment"), the ELs are separated from the GP lanes by concrete barrier. In the Northern Segment, the EL/GP separation changes to double-striped solid lines. The I-15 corridor typically provides 5 northbound GP lanes and 5 southbound GP lanes.

HOV Rules

Vehicles that have 2 or more occupants (also known as "high-occupancy vehicles" or "HOVs") can use the ELs for free without needing a transponder. All single-occupant vehicles (or "SOVs") are responsible for paying the posted toll.

Transponder Rules

All SOVs must have a FasTrak transponder to use the facility. HOVs (carpools, vanpools, and transit), clean air vehicles, and motorcycles are not required to have a transponder to use the facility.

Operating Rules

Southbound usage of the ELs is heaviest during the AM peak. Therefore, on Mondays through Thursdays, during the AM peak period, the facility is reconfigured such that the Middle and Southern Segments operate with 3 ELs in the southbound (SB) direction. This leaves only 1 EL operating northbound (NB). During all other times of the day, the ELs are configured to provide 2 ELs in each direction.

3. Goals, Objectives and Performance Measures

In collaboration with SANDAG and building on the I-15 Corridor Management Team (CMT) Charter, a comprehensive list of performance measures was proposed in the *I-15 Express Lanes Operational Study Performance Measures Technical Memorandum* for monitoring the I-15 corridor operations. The I-15 corridor goals and objectives will be monitored by the performance measures shown in Table 1.

Table 1: SANDAG I-15 Corridor Goals and Objectives

Goals and Objectives		Related Performance Measures
Goals	Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls	• % of EL vehicles traveling as SOVs • % of EL vehicles carrying 2 people (HOV2) • % of EL people traveling as HOV3+ • Transit ridership
	Generate sufficient revenue to sustain I-15 Express Lanes operations	• Express Lanes Revenue • Estimated Express Lanes Operating Costs • Estimated Net Revenue (revenue less operating costs)
	Minimize O&M costs	• Annual average cost incurred per trip served
Objectives	Optimize and maintain I-15 Express Lane trip reliability	• EL Travel Times (daily and peak period) • EL Speeds • EL 90th percentile travel times
	Reduce I-15 corridor (GP and EL) person and/or vehicle delay	• EL vehicle-hours of travel (VHT) • EL vehicle-hours of delay (VHD) • GP Travel Times (daily and peak period) • GP Speeds • GP VHT • GP VHD
	Improve I-15 corridor (GP and EL) person and/or vehicle throughput	• EL vehicle throughput • EL VMT • EL person-miles traveled • GP vehicle throughput • GP VMT • # of FasTrak transponders and active accounts
	Improve efficiency in the Express Lanes	• EL person throughput • Average FasTrak user trip length • Express Lanes violation rates • Frequency & Duration of HOV ONLY events
	Improve transit service performance	• Transit on-time performance • Transit peak load factor
	Reduce incidents and travel delays	• Number of travel incidents per year from CHP

4. Data Sources

Data from several different sources were extracted and processed for developing various performance measures. Broadly, the data sources fall under the following categories:

1. Account Management System (AMS) for the I-15 Express Lanes: This portal (provided by TransCore) is used to extract various data elements related to the I-15 EL toll collection system including (but not limited to) the following:
    - hourly traffic volumes at key EL mainline tolling locations
    - point to point traffic from entry to exit points on the EL system
    - HOV /SOV percentage shares (with additional data from SANDAG)
    - vehicle miles of travel (VMT) estimates
    - vehicle hours of travel (VHT) estimates
2. Caltrans Performance Measurement System (PeMS) System: The traffic data displayed on the map is collected in real-time from several individual detectors. These sensors span the I-15 corridor (General Purpose Lanes and Express Lanes) across the study area. Since the I-15 corridor has sections which have moveable barriers, the PeMS system does not accurately depict the parameters such as traffic volumes, speeds, travel times, and delays within the ELs; however, this data is available for the GP lanes.
3. National Performance Management Research Data Set (NPMRDS) Speed and travel time data: This dataset, which is powered by INRIX®, provides detailed travel time and speed data for the GP lanes and EL.
4. Transit data report (from SANDAG, MTS): This data set includes transit ridership in the corridor, transit on-time performance and transit peak load factors.
5. Violation data: This data set, provided by SANDAG staff, includes summaries of the violation rates at a few key locations along the I-15 Express Lanes.

The raw Caltrans PeMS data required a thorough review and processing prior to use in analysis to ensure reasonableness of the results. The first step in this process was to identify the proper datasets to use on the PeMS website and download the PeMS data. The raw compressed files were downloaded and organized by data type and year. Data was filtered to include only the I-15 corridor data, and an SQL Database and tables were developed. Each source folder of PeMS data and file was read, and each line (row) of data within each file was parsed and imported into the SQL Database. Partially imported data was spot-checked, and data conversion logic errors were corrected. SQL Views were created to aggregate, group, and sum the data. Finally, the SQL Views were exported for developing summaries of data.

Limitations of Data

- PeMS data is sometimes not of high data quality. The health of the detectors was generally good for the I-15 ELs and GP lanes, but in some cases a few detectors may have not collected data for a few hours on some specific days. To overcome any such data gaps, the analysis also encompassed all days in the year and included multiple years of data.
- The speed data from INRIX® is measured and summarized for EL and GP within the database as segments called traffic message channels (TMCs). Occasionally, these TMCs may be longer in length than a typical mainlane GP logical segments. Also, the INRIX data is available only as a sample, but this did not affect the quality of the overall speed or travel time estimates.

- For calculations such as VMT, VHT and VHD for the ELs, the volume component was only available at discrete locations (from AMS). As such, the volumes at other adjacent locations is only an estimate, based on the nearest available EL location with detailed data.

5. Overview of Performance Measures Analyzed

The remainder of this memorandum will be focused on the following performance measures, each of which are related to the I-15 corridor's goals and objectives identified in Table 1. The performance measures have been organized as follows:

- Traffic Volumes on EL and GP lanes
- Speeds and Travel Time
- Vehicle Occupancy
- VMT, VHT, VHD, Person-miles traveled
- Revenue and Operating Costs
- Express Lane Trip Length
- FasTrak Accounts and Users
- Travel Incidents
- Transit Trends for I-15 Corridor

5.1. Traffic Volumes on EL and GP Lanes

Based on a review of the 12-month period from June 2018 through May 2019, the ELs served approximately 68,500 trips per day, according to data from the TransCore AMS system. On average, the weekday usage of the ELs in the SB direction (38,500 trips per day) was almost 30% higher that usage in the NB direction (29,900 trips per day). The higher southbound volume helps explain why the lanes are configured to provide an extra SB lane during the AM peak period.

This section provides an overview of the following performance measures:

- EL vehicle throughput
- GP vehicle throughput[1]
- EL person throughput

Monthly Traffic Trends on Express Lanes

The monthly variations in traffic were evaluated over a period of time from 2016 to early 2019 to identify any seasonal variations in traffic.

Data Sources

AMS website (Traffic by Location Details table)

Methodology and Analysis

Traffic data from AMS was summarized by month. Figure 1 represents northbound (NB) and southbound (SB) monthly variations in average daily traffic from 2017 through early 2019. The figure focuses on three locations (Miramar Way, Caramel Mountain Road, and Via Rancho Parkway) that are indicative of the

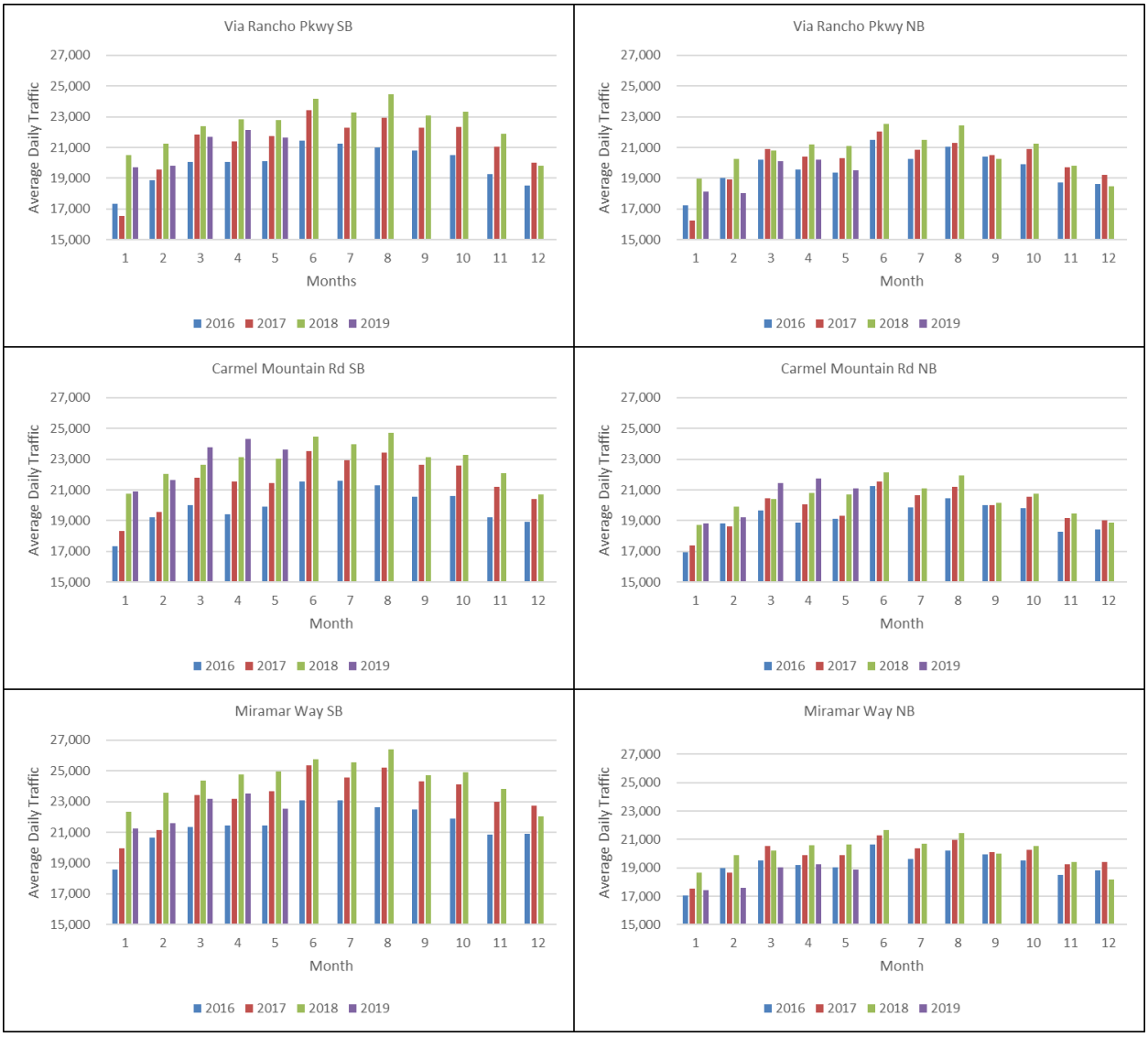
[1] GP person throughput could not be estimated because there was no survey data related to vehicle occupancy for GP lanes.

corridor's operations. The monthly variations are based on average daily traffic to normalize for the different number of days in each month.

Key Findings

- Usage of the ELs is highest during the summer months from June through August.
- The EL is generally least utilized in the winter months of November through February.
- Comparing trends in Figure 1, the average daily demand is generally slightly lower for the NB compared to the SB ELs. Some of this can be attributed to the higher capacity (additional third lane) being available to the SB ELs in the AM peak period (only two ELs are available for NB in its typical peak period, i.e. the PM peak).

Figure 1: Monthly Variations of Average Daily EL Traffic



EL Vehicle Throughput

The average EL vehicle throughput is a good indicator the I-15 EL operations. Steady hourly vehicle throughput, especially during peak hours, is critical to maintaining efficient traffic operations on the EL. If peak-period throughput starts to stagnate or decline over time, it may indicate that the facility has reached its peak-period capacity.

Data Sources

AMS website (Traffic by Location Details)

Methodology and Analysis

Hourly vehicle throughput for an average weekday for EL is illustrated for several key mainline locations along the I-15 study corridor in Figure 2, Figure 3 and Figure 4. The graphics run progressively from north to south. These figures show hourly traffic volumes for average weekdays at key EL mainline locations for 2016 through the first half of 2019 (it should be noted that the 2019 data does not include counts from July onwards).

Key Findings

- Overall hourly traffic demand on the ELs is not significant except during the peak hour in the peak direction (southbound in the AM peak and northbound in the PM peak). There is a strong directional component to the hourly demand that is noticeable during the peak periods.
- Based on Figure 2 and Figure 3, there is a small increase in traffic for the southbound EL locations during the PM peak (in the northern and middle sections). By comparison, northbound ELs carry very low volumes during the AM peak period. This can perhaps be attributed to the fact that only one northbound EL is available during this time.
- Based on Figure 4, the southern section (from south of Sabre Springs Drive to SR-163) shows a small peak in the southbound direction during the PM peak (the dominant direction is still northbound).
- The AM peak hour around Bernardo Center Drive and Carmel Mountain Road in the southbound direction occurs at around 7 AM. The PM peak period at these same locations in the northbound direction occurs between 3 and 4 pm, and it extends a little longer than the southbound AM peak.
- The relative EL hourly traffic profiles have been consistent from 2016 through 2019.
- The EL vehicle throughput shows growth at some locations between 2016 and 2019. It is predominantly seen in the southbound direction during the AM peak period, where the demand continues to grow. A likely contributor to this growth is the availability of the additional third southbound lane on the EL during the AM peak, whose presence allows the traffic to continue to increase year over year.

GP Vehicle Throughput

Data Sources

PeMS

Methodology and Analysis

Similar to the EL vehicle throughput, hourly vehicle data was summarized at similar GP locations along the I-15 corridor from various detectors on the PeMS system. This data is illustrated for several key GP mainline locations along the I-15 study corridor in Figure 5 through Figure 7.

Key Findings

- As expected, hourly traffic on the GP lanes is much more evenly spread than on the EL. At most locations, two peak periods (one each in the AM and PM) are observed for both northbound and southbound directions.
- The GP vehicle peak hour throughput does not show significant growth between 2017 and 2019. For example, at Carmel Mountain Road, in the northbound direction, the PM peak hour (5 PM) traffic changed from 7,560 to 7,580, representing a minimal growth of 0.2 percent.

Figure 2: Hourly Volumes for Northern Section of Express Lanes

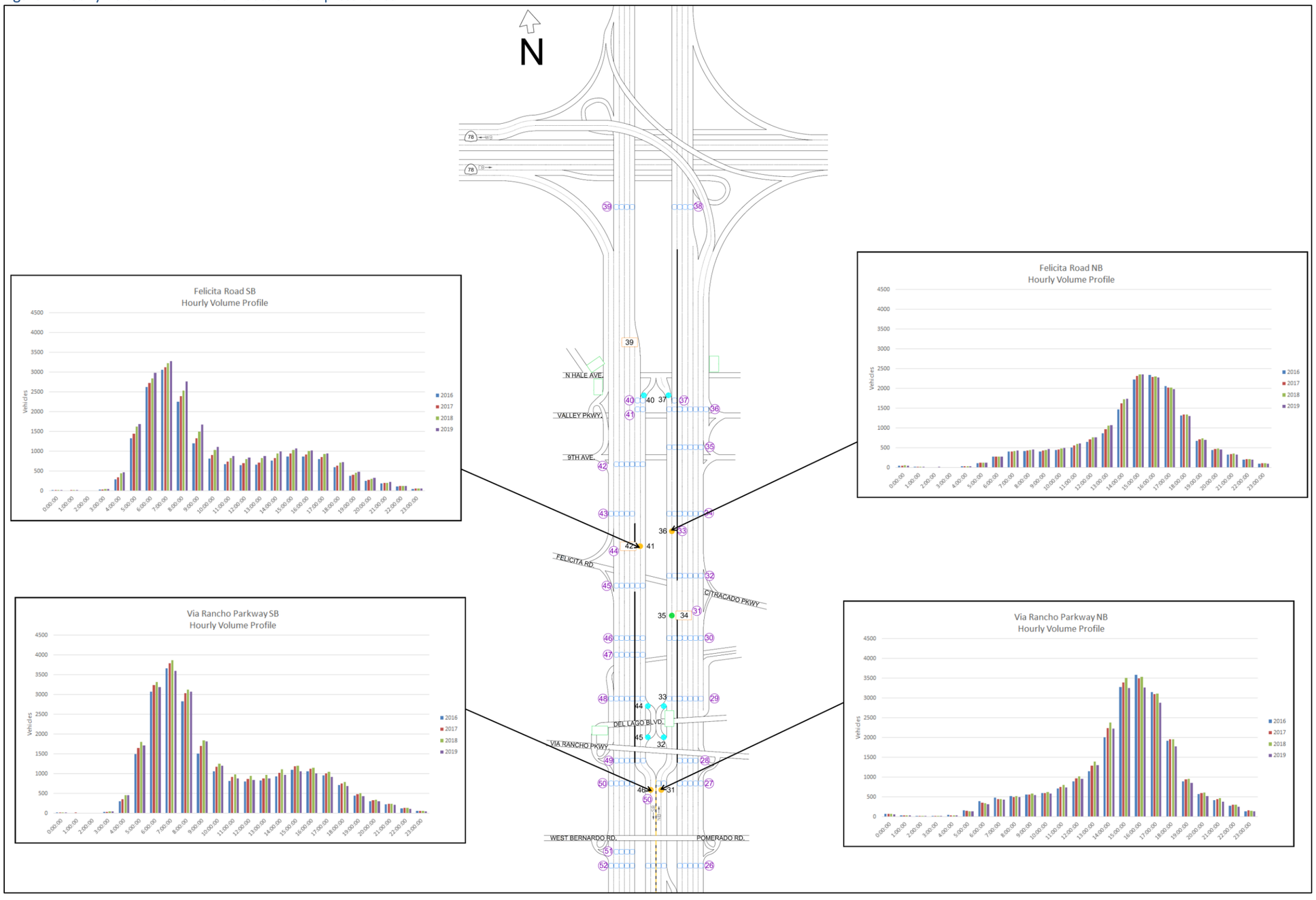


Figure 3: Hourly Volumes for Middle Section of Express Lanes

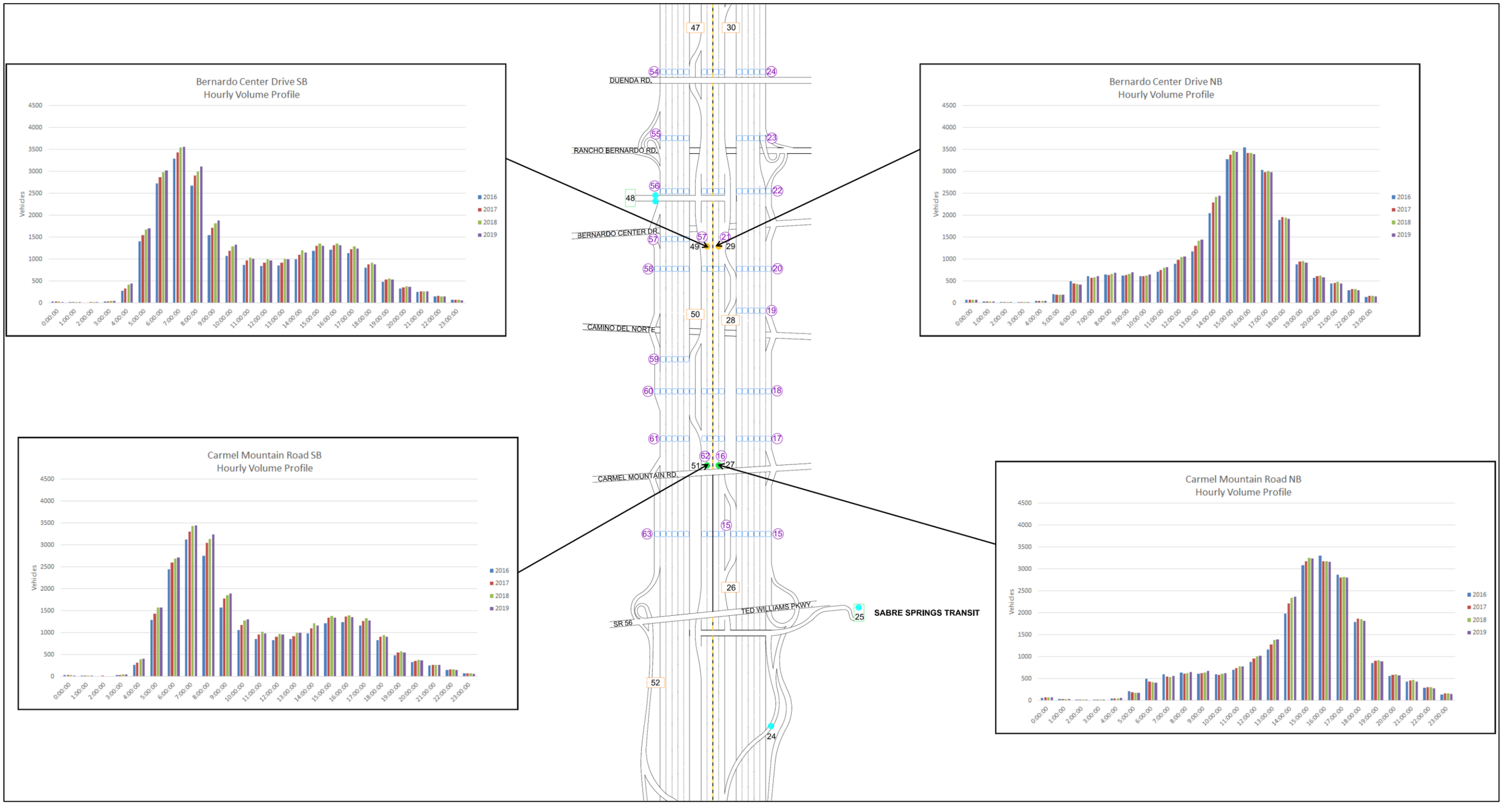


Figure 4: Hourly Volumes for Southern Section of Express Lanes

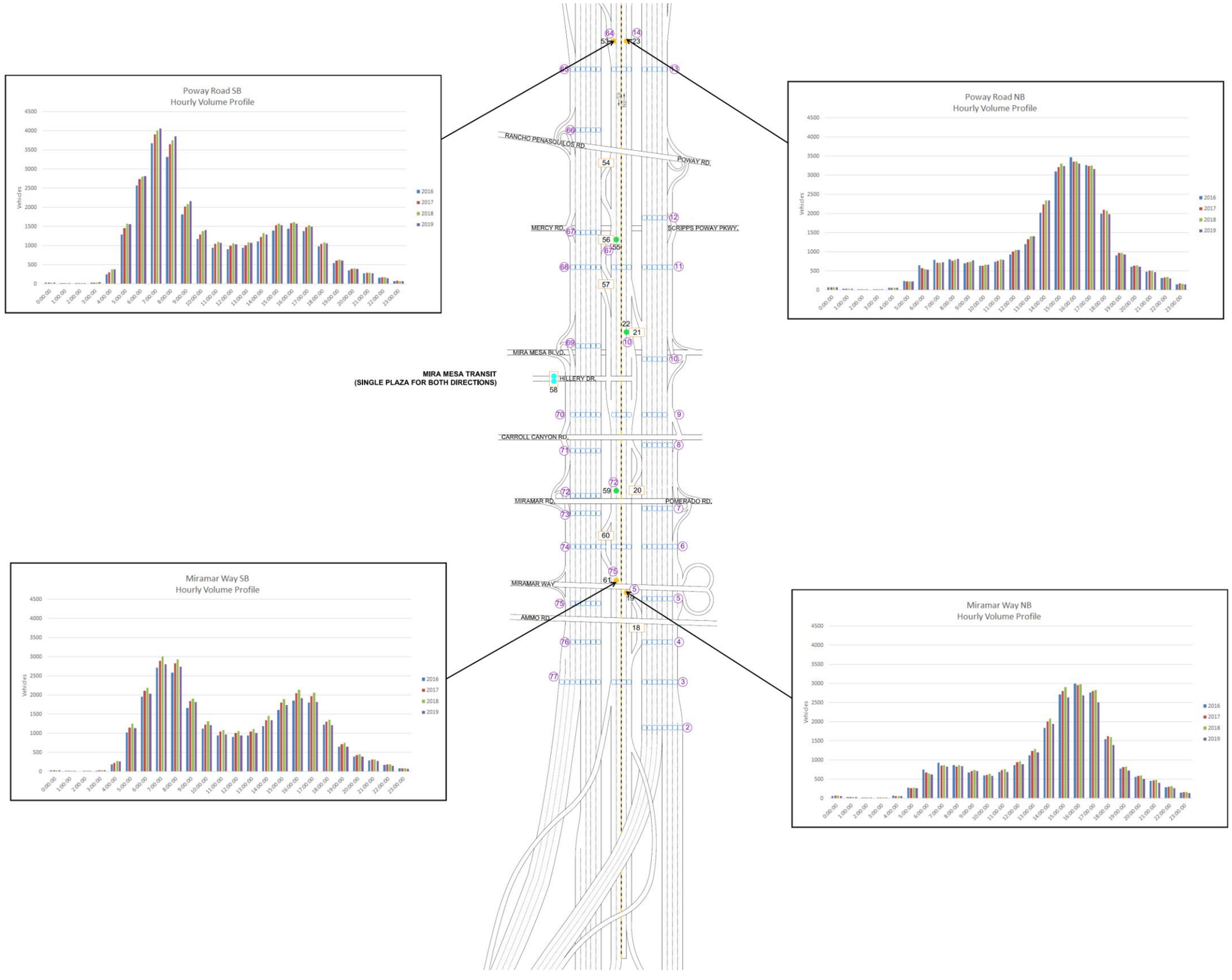


Figure 5: Hourly Volumes for Northern Section of GP Lanes

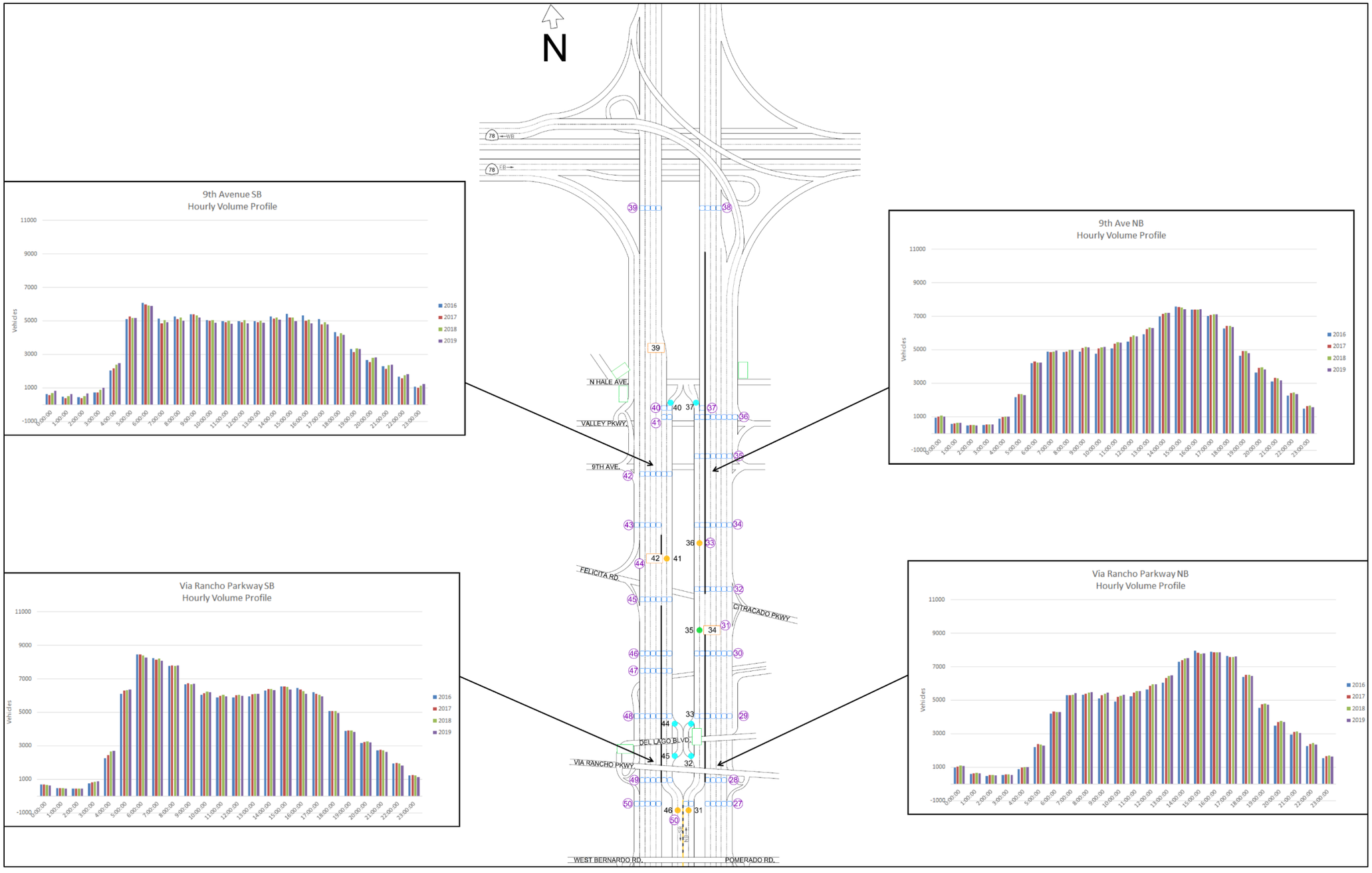


Figure 6: Hourly Volumes for Middle Section of GP Lanes

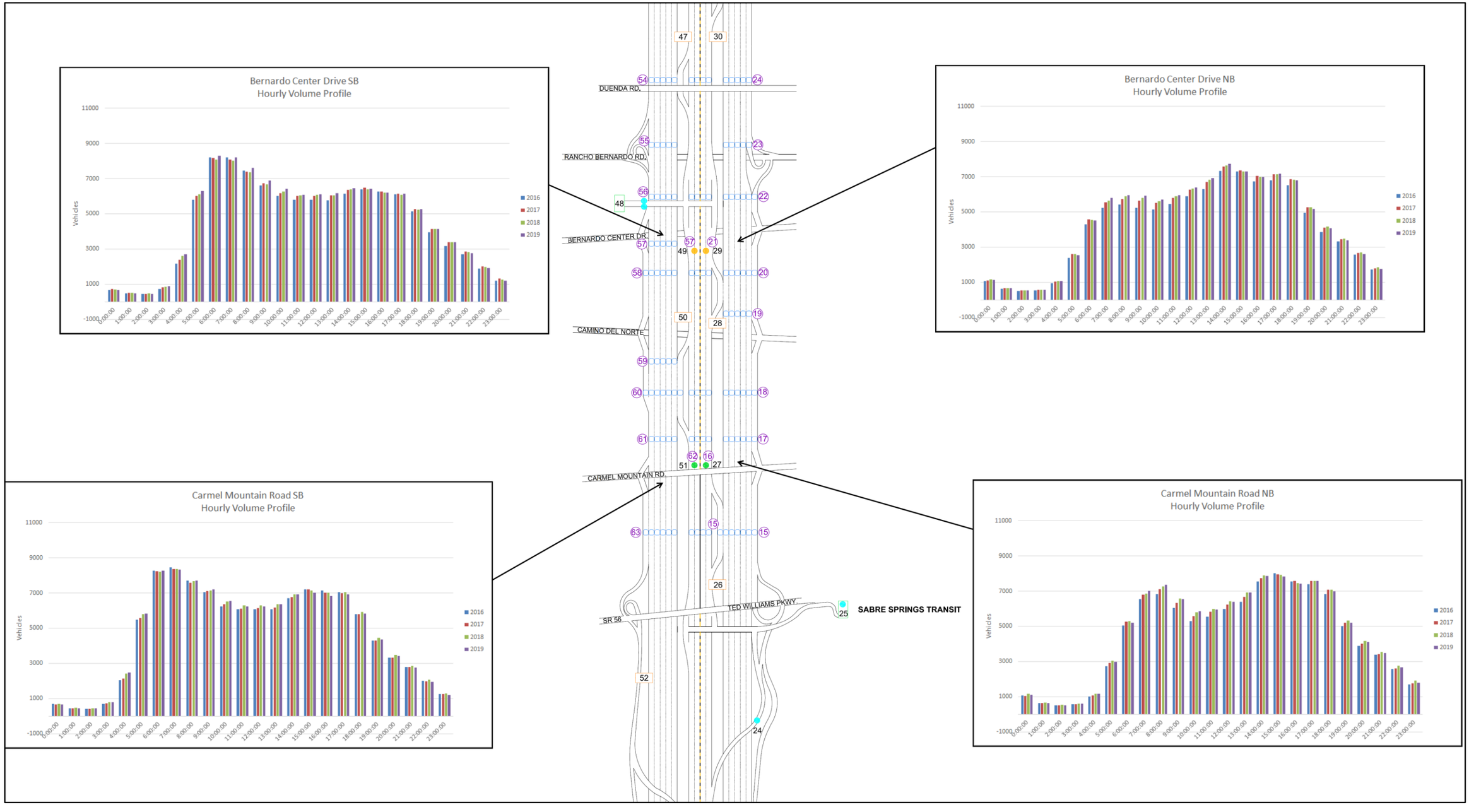
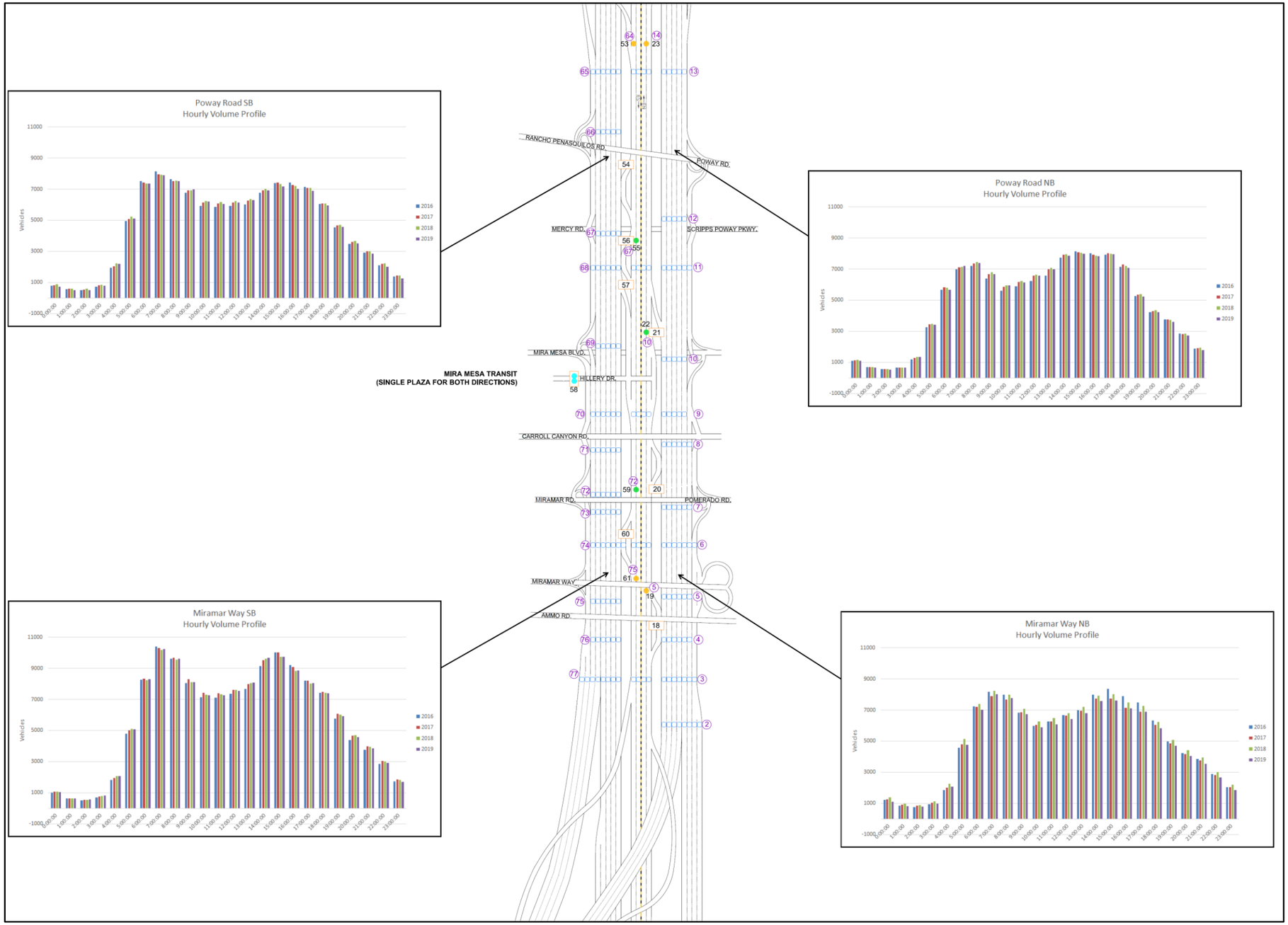


Figure 7: Hourly Volumes for Southern Section of GP Lanes



EL Person Throughput

Data Sources

Traffic volumes are from the AMS website (Traffic by Location Details) and the vehicle occupancy data (presented in a Section 5.3 of this memo) is from SANDAG.

Methodology and Analysis

Hourly person throughput for an average weekday in 2018 for EL is shown in Table 2. The table includes data at selected locations along the corridor.

Table 2: Hourly EL Person Throughput

	NB		SB	
	AM Peak (7-9 AM)	PM Peak (4-6 PM)	AM Peak (7-9 AM)	PM Peak (4-6 PM)
Miramar Way	3,526	10,417	8,623	7,431
Poway Rd	2,713	11,361	10,688	5,495
Carmel Mountain Rd	2,060	9,954	9,441	4,859
Via Rancho Parkway	1,747	11,771	10,717	3,990

Key Findings

- The directionality can be seen by comparing the NB and SB sections between the AM and PM period.
  - In the NB direction, EL person throughput in the PM peak is *over four times higher* than during the AM peak.
  - In the SB direction, EL person throughput in the AM peak is about two times higher than during the PM peak.
- At most locations, the peak period EL person throughput in the SB direction during the AM peak is generally comparable to the throughput in the NB direction during the PM peak. The one exception is Miramar Way, at which NB throughput during the PM peak was over 20% higher than SB throughput during the AM peak.

5.2. Speeds and Travel Time

Median and Planning Time Speeds

Data Source

NPMRDS (powered by INRIX®)

Methodology and Analysis

The I-15 study corridor speeds for the GP and EL are summarized on speed heat maps for the weekdays based on median and planning time speeds of all recorded trips in the dataset.

The planning time speeds correspond to 90th percentile travel conditions. In other words, on an average weekday, 90% of the observed/recorded speeds were equal to or faster than the planning speeds depicted. This provides a measure of the reliability of speeds and travel times for the EL. The speed heat maps in Figure 8 through Figure 13 use speed data reported by the NPMRDS (powered by INRIX®) in 5-minute increments. The dark green colors on the heat maps indicate free flow speeds (65 mph or more) while the yellow, orange

and red colors indicate slower speeds. Figure 8, Figure 9, Figure 10 and Figure 11 provide an overview of the median speeds for southbound EL, northbound EL, southbound GP lanes and northbound GP lanes respectively. Figure 12 and Figure 13 depict planning time speeds for the northbound and southbound ELs.

Figure 8: Heat Map – Median Speed – SB EL – Average Weekday

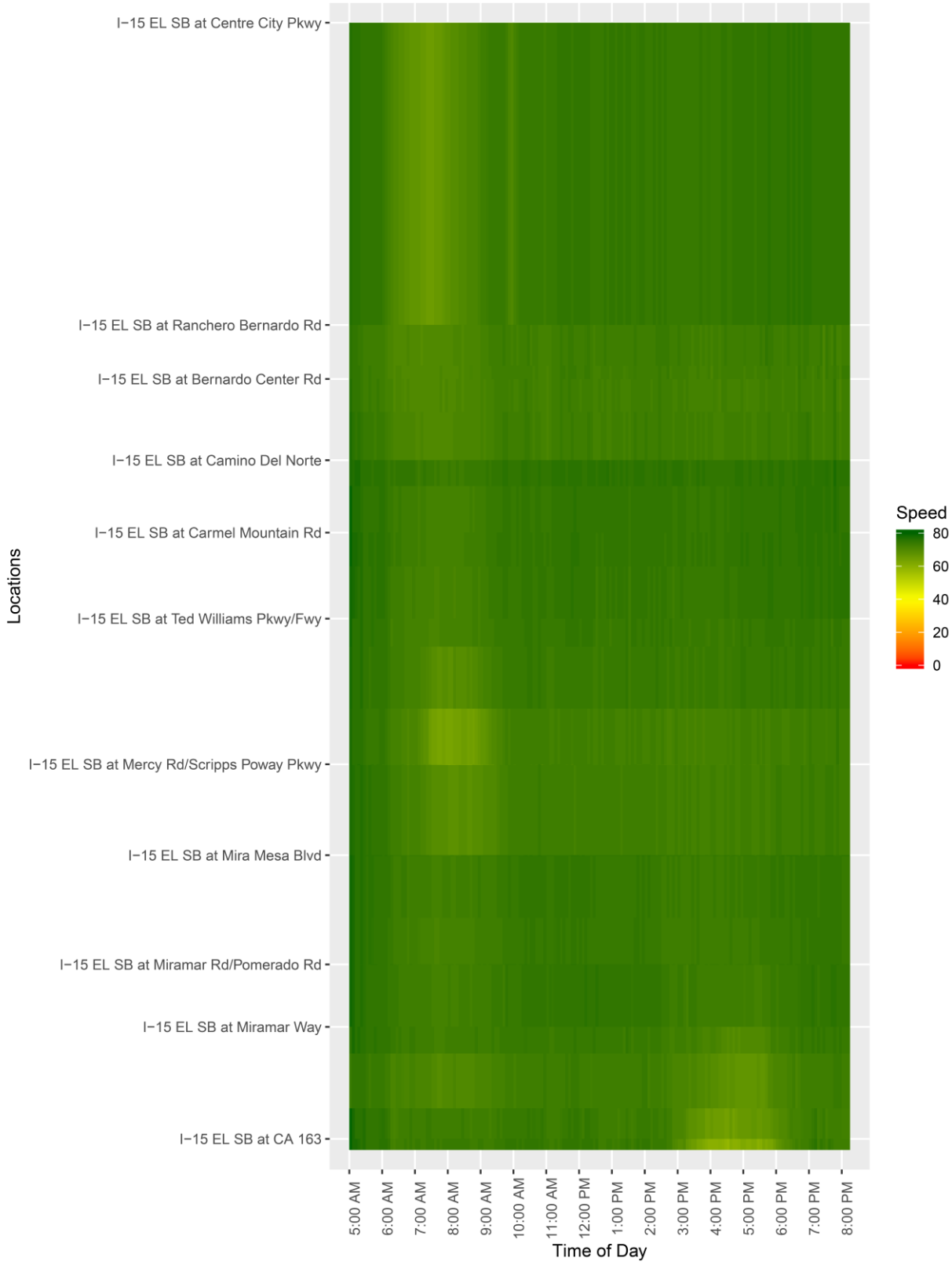


Figure 9: Heat Map – Median Speed – NB EL – Average Weekday

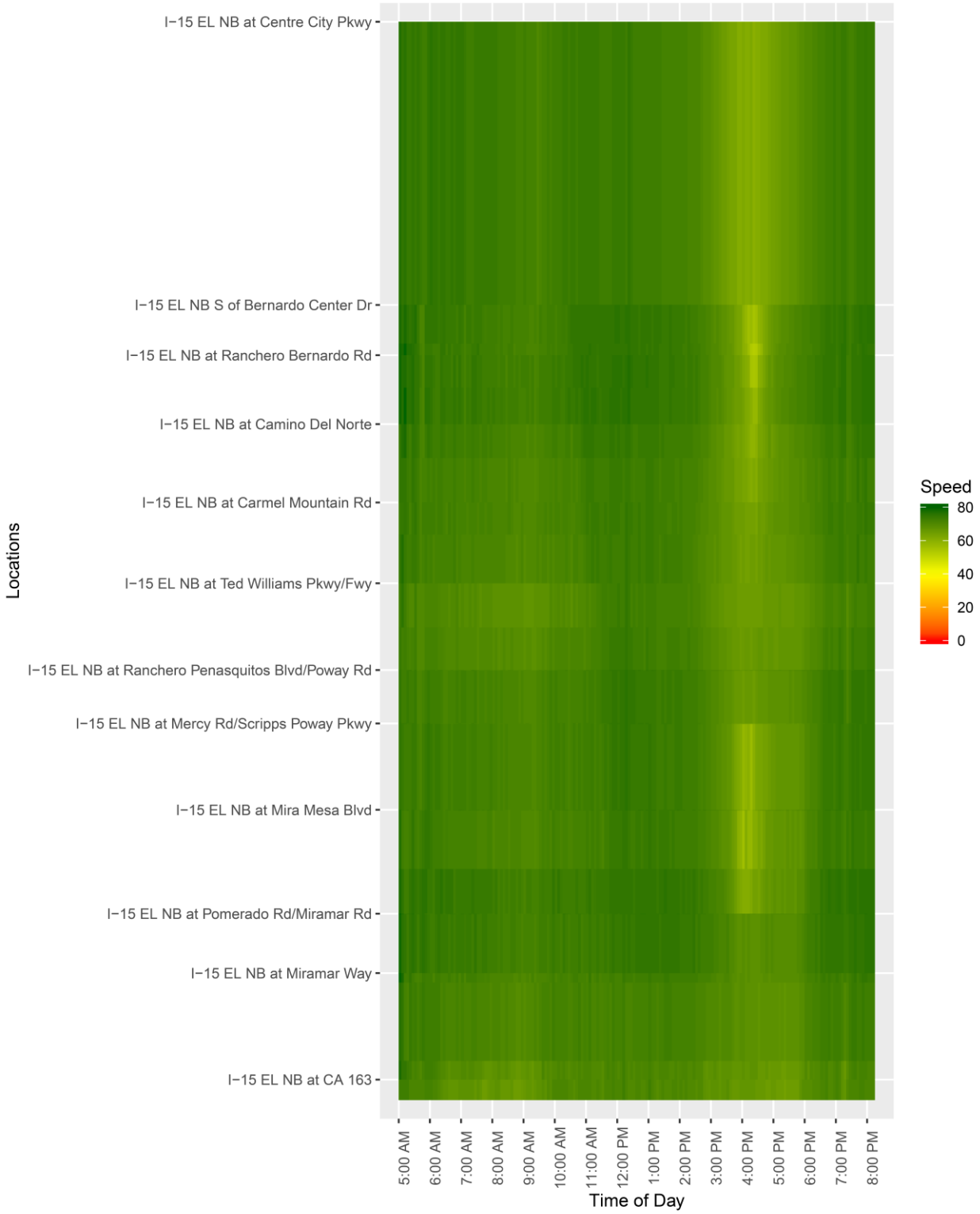


Figure 10: Heat Map – Median Speed – SB GP – Average Weekday

Figure 11: Heat Map – Median Speed – NB GP – Average Weekday

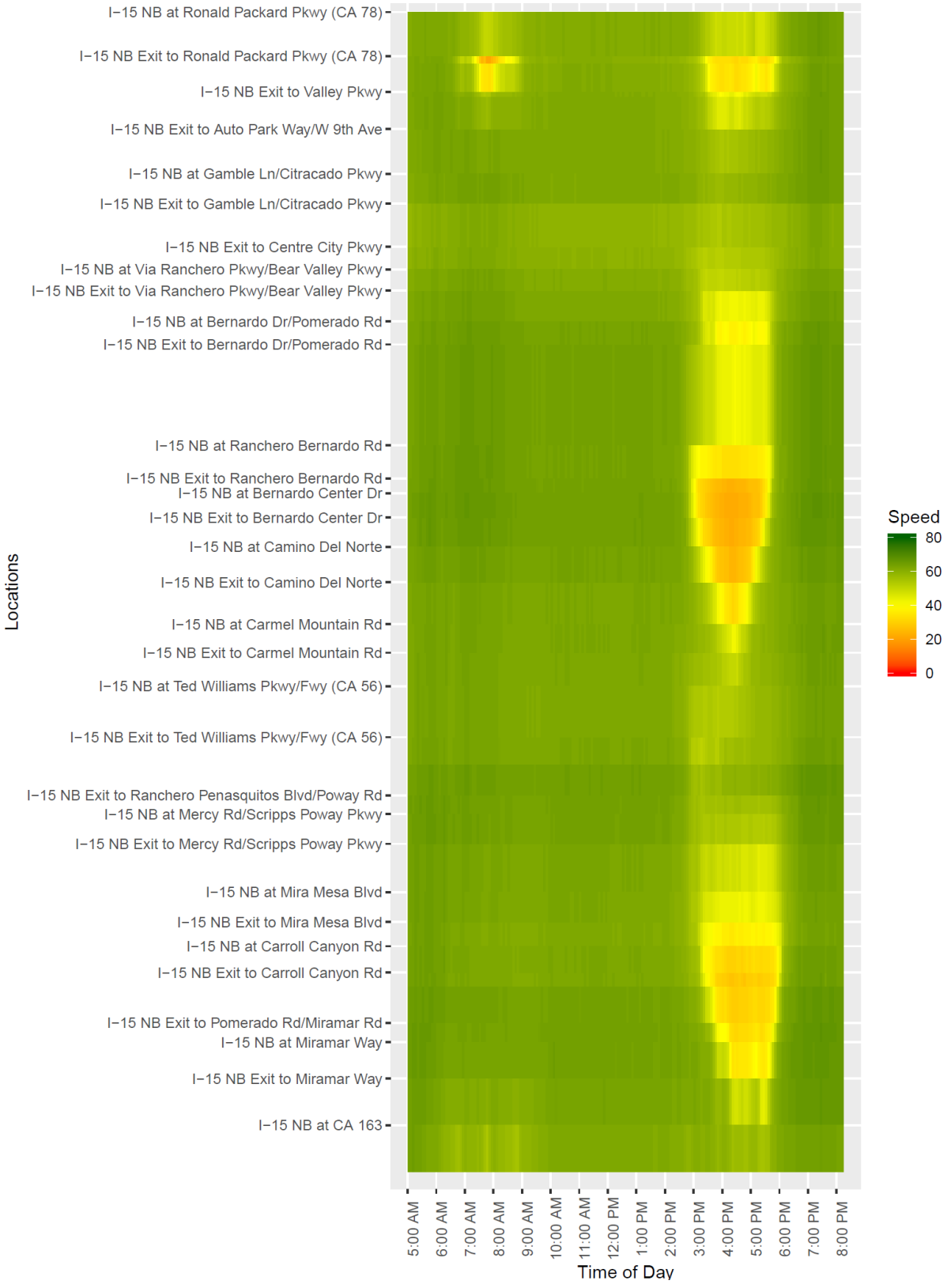


Figure 12: Heat Map – Planning Speed – SB EL – Average Weekday

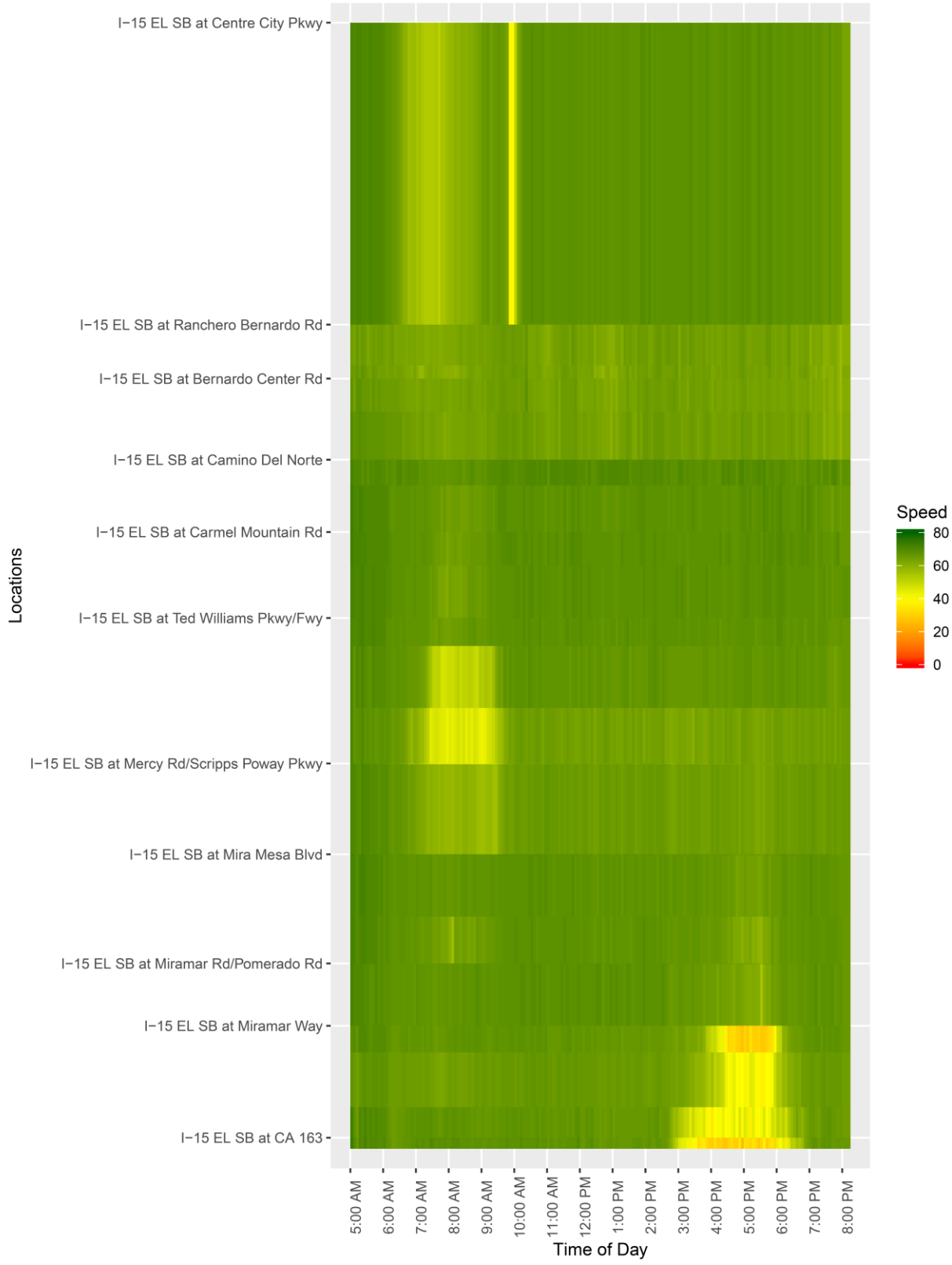
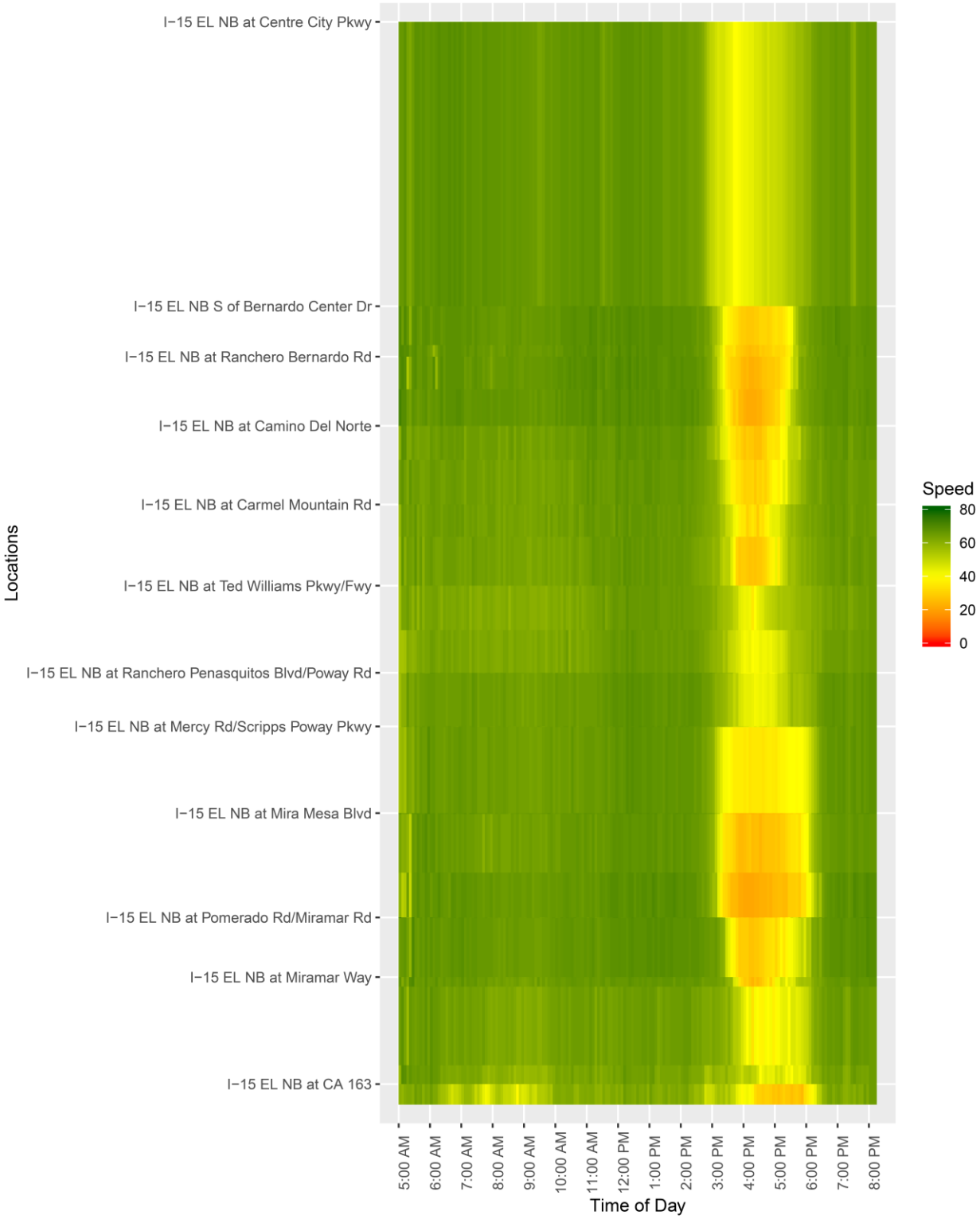


Figure 13: Heat Map – Planning Speed – NB EL – Average Weekday



Key Findings

Express Lanes

- The median speed heat maps illustrate that the speeds for both AM and PM periods are generally reasonable through most of the day. Some brief periods of slower speeds are observed for southbound during the AM peak and northbound during the PM peak.
- The southbound AM has fewer patches of yellow (median speeds in the AM peak were generally higher than 50 mph compared to 40-50 mph during the PM peak) compared to the northbound PM, likely due to the availability of additional capacity in the AM (3 ELs southbound).
- Weekend days (Saturdays and Sundays) have minimal reductions in median speed relative to free flow speeds reflecting lower demand on weekends.
- Planning speeds: Between 7 and 9 AM, there are some sections of I-15 SB EL that have a 10% possibility of experiencing speeds of 40 mph or less. For the northbound PM (between 3 and 6 PM), there are some occasions when the EL traffic slows to between 30 and 40 mph. The median speeds do not show comparable speed reductions.
- At the southern end of the facility, during PM peak periods, planning speeds in the SB EL dip into the 25-30 mph range (see Figure 12). This suggests that the two SB Express Lanes in this portion of the facility may be operating at (or near) capacity or that there is bottleneck just downstream where the SB ELs merge into the SB GP lanes. If SANDAG were to change its PM peak period configuration to 3NB + 1 SB, this portion of the southbound lanes could become very congested.

General Purpose Lanes

- GP lanes show congestion SB from 6:30 to 8:30 AM, with speeds slowing to around 30 mph.
- GP lanes show congestion SB from 3 to 6 PM, with speeds slowing to around 30 mph.

Typical Travel Times and Travel Time Reliability

Travel time reliability is used to measure the extent of potential delays on a facility. Specifically, in this analysis a range of observed travel times are depicted to illustrate the degree of consistency or dependability of the ELs.

Data Source

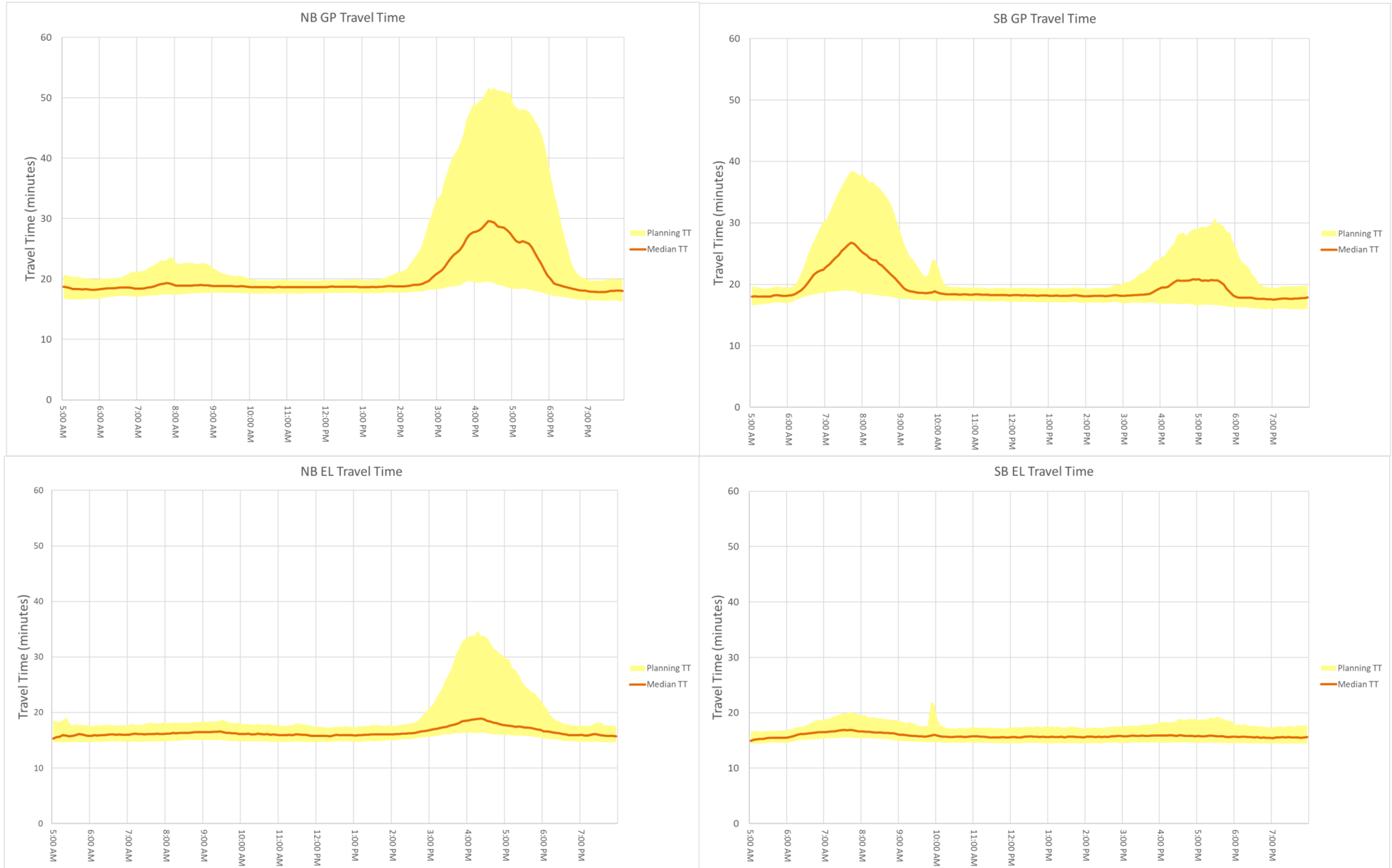
NPMRDS (powered by INRIX®)

Methodology and Analysis

Similar to the speeds, typical travel times were estimated for a through trip for the entire length of the I-15 study corridor using the EL and GP lanes on an average weekday. For this analysis, travel time data from typical weekdays (Tuesdays through Thursdays) was extracted for 2018 from the NPMRDS dataset. The difference between the 10% and 90% travel time for each facility is shown in the table and graphs below.

In Figure 14, the red lines depict the travel time for a complete through trip (from one end of the EL to the other, i.e., from the southern end at SR 163 to the northern end at SR 78 or vice versa) in each direction based on median speeds. The yellow area indicates the lower bound (10 percent of vehicles will experience these travel times or faster) and the upper bound (90 percent of vehicles will experience these travel times or faster) on the travel times for a through trip on the I-15 corridor.

Figure 14: Median and Planning Time estimates for Average Weekday to travel entire I-15 Corridor



Key Findings

- The EL generally shows reliable travel times (the median speed does not significantly differ from the 10% and 90% planning travel times) with the exception of NB in the PM peak.
- Figure 14 indicates that the planning travel time for northbound travel during the PM peak period is more than 50 percent higher than the corresponding median travel time. This is further corroborated by the planning speeds shown in Figure 9 and Figure 13. These two figures show that the EL NB traffic experiences median speeds near 45 mph but can experience significantly lower planning time speeds (10% of vehicles may experience speeds as low as 25 to 30 mph).
- The EL travel times are more reliable for southbound travel than the northbound travel (likely due to the availability of the additional EL lane for southbound travel AM peak).
- The GP shows reliable travel times during the off-peak periods, but during the peak periods there are some travel time uncertainties. The southbound GP lanes exhibit variable travel times for both AM and PM peak periods.

5.3. Vehicle Occupancy

While one of the objectives of the I-15 EL is to improve vehicle throughput, the efficiency of the ELs can be improved by increasing the person throughput. Person throughout for the EL can be improved with an increased percentage of high-occupancy vehicles (HOVs) and by having an overall higher average vehicle occupancy.

Percentage of SOV, HOV2 and HOV3+ Vehicles

Data Source

SANDAG Vehicle Occupancy Surveys

Methodology and Analysis

One of the key performance measures that is useful to measure HOV share is the HOV/SOV split on the ELs. Figure 15 includes the summary of the survey data conducted in Spring 2019 for four selected EL mainline locations. For this analysis, motorcycles were grouped with SOVs, and vanpools and buses were assumed to be HOV3+.

Figure 15: Percentage of Vehicles Traveling as HOVs at Selected Locations

Key Findings

- Figure 15 illustrates that the southbound AM had the highest share of SOVs (ranging from 62 to 71 percent depending on location) compared to southbound PM, northbound AM, and northbound PM. This is likely due to the availability of an additional third southbound lane on the ELs (available Monday through Thursday for AM peak period only). The additional capacity leads to lower traffic densities and therefore lower toll rates. These lower rates (and reliable travel times) in turn make the southbound Express Lanes more attractive to SOVs in the AM peak period. By comparison, no additional lane is available for the EL traffic in the northbound direction in the PM period.
- The non-peak direction (generally northbound in the AM, and southbound in the PM) generally had high percentages of HOVs, with the SOV shares typically ranging from 35 to 50 percent for the northbound AM and southbound PM typical off-peak directions.
- Figure 15 also indicates that the overall HOV3+ share is low – at most locations, the HOV3+ share of total EL traffic was less than 8 percent, the only exception being at Via Rancho Parkway for the NB direction in both the AM and PM peak periods. Since **all** vehicles with 2 or more occupants travel toll-free, there is no real price incentive for HOV3+ vehicles. This perhaps contributes to their low share of total traffic.

Average Vehicle Occupancy

Data Source

SANDAG

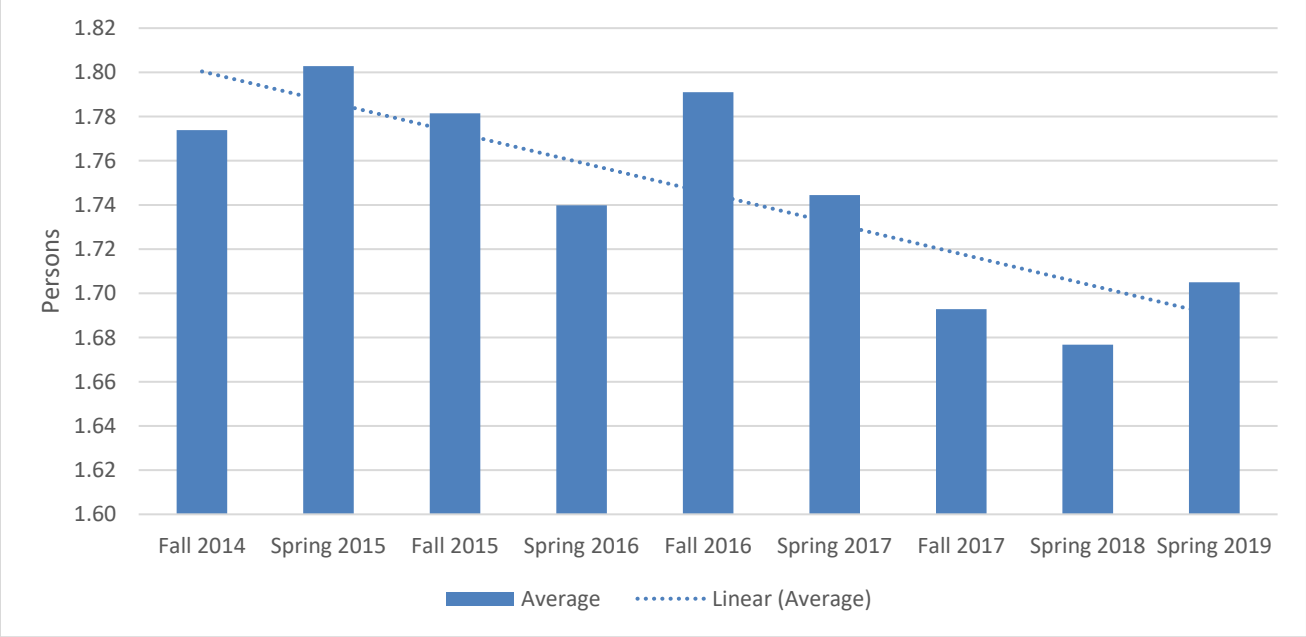
Methodology and Analysis

Another measure that is useful to measure the EL efficiency (as it relates to the person throughput) is the average vehicle occupancy (AVO). AVO data was provided by SANDAG for four specific EL mainline locations at Miramar Road, Poway Road, Carmel Mountain Road and Via Rancho Parkway, as illustrated in Table 3 and Figure 16. Based on the summaries provided, the AVO varied from 1.65 to 1.84. This yields an average vehicle occupancy of **1.72** for the corridor based on the data available.

Table 3: Average Vehicle Occupancy at Selected Locations

	Miramar Road	Poway Road	Carmel Mountain Road	Via Rancho Parkway	Average
Spring 2016	1.72	1.73	1.77	1.73	1.74
Fall 2016	1.78	1.79	1.84	1.76	1.79
Spring 2017	1.71	1.75	1.71	1.81	1.74
Fall 2017	1.65	1.70	1.72	1.70	1.69
Spring 2018	1.71	1.66	1.71	1.63	1.68
Spring 2019	1.73	1.66	1.66	1.76	1.70

Figure 16: Biannual Average Occupancy



Key Findings

- The overarching trend from Figure 16 shows a decrease in vehicle occupancy over time.
- From Fall 2016 to Spring 2018, the AVO was generally decreasing, falling from about 1.8 occupants per vehicle in Spring 2015 to roughly 1.68 in Spring 2018.
- In Spring 2019 there was a small increase in occupancy. Time will tell whether this represents a turnaround point or simply a temporary interruption to a long-term downward trend.

Percentage of Persons in HOV Vehicles

Data Source

SANDAG

Methodology and Analysis

The percent of EL people traveling in HOVs can be estimated by applying the share of SOVs, HOV2 and HOV3+ vehicles and the appropriate occupancy factor to each of the vehicle occupancy categories of EL vehicles defined above (i.e., the percent of EL vehicles traveling as SOVs, percent of EL vehicles carrying 2 people, percent of EL vehicles traveling as HOV3+). Figure 17 includes the summary of the survey data conducted in Spring 2019 for four selected EL mainline locations. The occupancy of HOV3+ vehicles was assumed to be 3.1 persons.

Figure 17: Percentage of Persons Traveling at Selected Locations, by Occupancy Type

Key Findings

- At virtually every location, during virtually every time period, over half of people in the EL traveled in HOVs. The only exceptions were Poway Rd. and Carmel Mountain Rd. during the AM peak.
- During the PM peak, in both directions, nearly 75 percent of persons in the EL were traveling in HOVs.
- Figure 17 indicates that the share of persons traveling in HOV3+ is relatively small, typically comprising less than 15 percent of the total EL throughput for a given peak period in a specific direction. The one exceptions are for the NB ELs at Via Rancho Parkway, where the HOV3+ share of person throughput was 30 and 20 percent for the AM and PM peak periods respectively.

Frequency of Occurrence of HOV-Only Mode

The EL operations are managed by increasing toll rates per mile incrementally as the demand increases. However, once the maximum per-mile toll rate of $1 is reached and the EL vehicle density is too high, the EL algorithm is designed to go into HOV-Only mode. “HOV ONLY” is displayed on the overhead signs when the Express Lanes are reaching full capacity. SOVs with FasTrak accounts should not enter the Express Lanes when “HOV ONLY” is displayed.

Data Sources

SANDAG

Methodology and Analysis

Based on data provided by SANDAG on the various instances of HOV-Only, the frequency of occurrence of HOV-Only on the ELs was analyzed by month and direction. Figure 18 illustrates the number of occurrences of HOV-Only by Month for northbound and southbound ELs. Figure 19 provides an estimate of the average duration of each HOV-only occurrence (shown as the average minutes that the EL stayed in HOV-Only mode).

Figure 18: Frequency of HOV-Only by Month

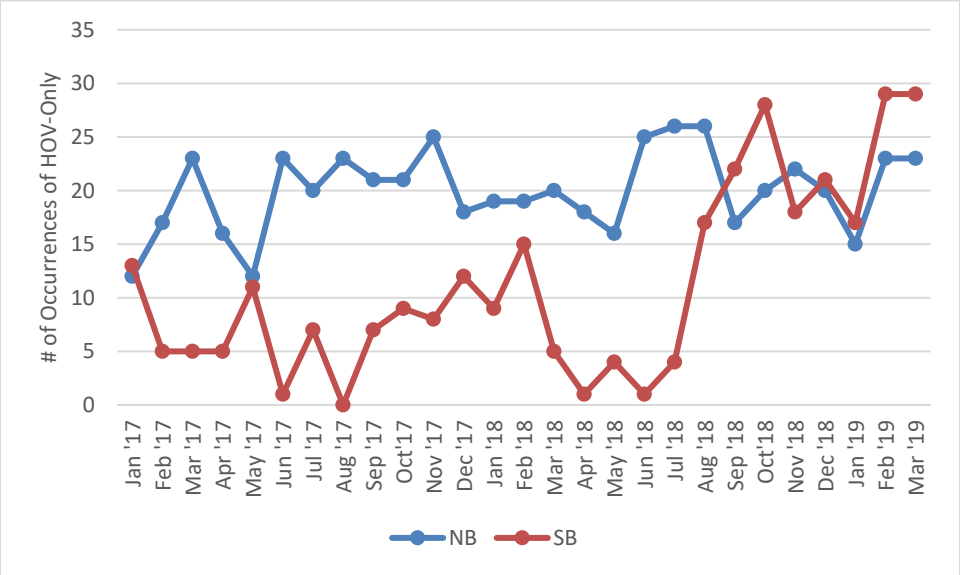
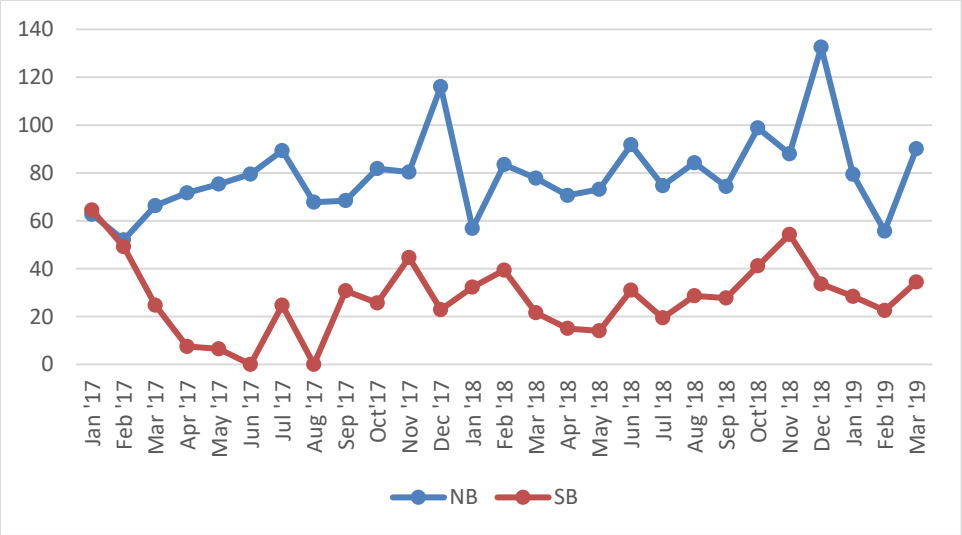


Figure 19: Average Duration (in minutes) of HOV-Only Mode per Occurrence



Key Findings

- From January 2017 through August 2018, the SB direction consistently had fewer occurrences of HOV-only mode than the NB direction. As Figure 18 indicates, the frequency of southbound HOV-only occurrences remained generally lower than 15 occurrences per month between January 2017 and July 2018.
- Yearly pattern shows consistent pattern of frequent occurrences of HOV only mode in the NB direction. As Figure 18 indicates, the frequency of northbound HOV-only occurrences remained higher than 15 occurrences per month with several months having more than 20 occurrences.
- From January 2017 through mid-2018, the northbound ELs functioned in HOV-only mode at least five times more frequently than the southbound ELs. This is likely due to the availability of additional EL capacity for the southbound during the AM peak (i.e., the peak direction for AM travel). But as noted above, the number of instances of southbound HOV-only mode have increased significantly since August 2018.
- Figure 19 indicates that the duration that the NB ELs stayed in HOV-Only mode was significantly higher than the SB ELs. In 2018, the NB ELs remained in HOV-Only for more than 80 minutes on average for each occurrence, while the SB ELs remained in HOV-Only mode for just 30 minutes.
- The hourly distribution of HOV-Only mode occurrences showed a pattern similar to the volumes. Southbound ELs have the nearly all of their occurrences in the AM peak while the northbound ELs have the majority of their occurrences in the PM peak.
- An analysis of the locations that go most frequently into HOV-only mode indicates that the 9th Ave SB, the Mira Mesa Transit, the SR 163 access, Miramar Road NB, SR 56 NB, and Rancho Bernardo access points go into HOV-only most frequently. The majority of these locations triggering the HOV-only mode in the northbound direction in the PM, with 9th Ave SB being of the few locations that frequently go into HOV-only in the AM period.

Violation Rates

Data Source

SANDAG provided violation survey data

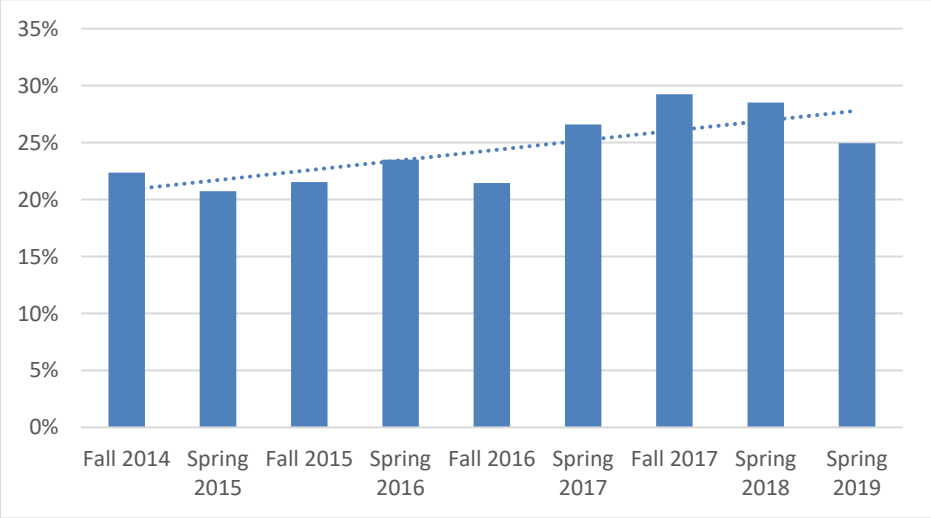
Methodology and Analysis

The percentage of transactions that were identified as violations at the point of detection were estimated and summarized at four selected locations. Table 4 illustrates the estimated violation rates at these four locations. Figure 20 represents a summary of the average violation rates estimated from all four locations.

Table 4: Estimated Violation Rates summarized at four selected locations

Time Period	Miramar Rd.	Poway Rd.	Carmel Mtn.	Via Rancho	Average
Fall 2014	21%	25%	22%	22%	22%
Spring 2015	21%	21%	18%	23%	21%
Fall 2015	20%	26%	23%	17%	22%
Spring 2016	25%	26%	21%	22%	24%
Fall 2016	21%	25%	18%	22%	21%
Spring 2017	27%	29%	29%	20%	27%
Fall 2017	29%	32%	30%	26%	29%
Spring 2018	29%	33%	28%	24%	29%
Spring 2019	25%	32%	27%	15%	25%

Figure 20: Average % Violations



Key Findings

- The overarching trend from Figure 20 shows an increase in violations over time, increasing from approximately 20 percent of violations in Spring 2015 to approximately 28 percent in Spring 2018.

- The highest violation rates were seen in Fall 2017 and Spring 2018. There was a small reduction in violations within the past year.

5.4. Vehicle Miles of Travel, Vehicle Hours of Travel and Vehicle Hours of Delay

These measures provide an estimate of the total vehicle miles of travel (VMT), vehicle hours of travel (VHT) and vehicle hours of delay (VHD) by combining the traffic volume data, the travel time from INRIX®, and distance for various segments of the I-15 EL.

VMT measures the amount of travel on the EL and GP lanes for a given period of time and is a measure of the sum of all miles traveled by all vehicles in the corridor during this period. VHT is a measure based on vehicle demand and travel time that illustrates the quality of service on the I-15 ELs. It allows planners and policymakers to compare performance of a facility or a corridor relative to other corridors or locations, and can be used to measure the economic costs of congestion. The lower the VHT for a given time period, the better the performance. VHD for a given period is estimated by subtracting the estimated VHT if all traffic were at free-flow speed from the actual observed VHT.

Vehicle Miles of Travel

Data Source

These metrics were calculated using volume, speed, travel time, and distance data. The EL data came from AMS (volume) and INRIX® (speed). The GP data came from PeMS.

Methodology and Analysis

VMT is estimated by multiplying the estimated volume for each logical segment and the distance for that segment, and aggregating the total VMT of all the logical segments across the entire day.

Table 5: Peak Period VMT Estimates

	7-9AM	4-6PM
NB EL	24,800	111,600
NB GP	311,000	367,100
NB %VMT in EL	7%	23%
SB EL	120,500	53,000
SB GP	318,300	271,600
SB %VMT in EL	27%	16%

Key Findings

- The vehicle miles traveled shows the high utilization of the EL in peak hours in the peak direction. The peak direction is clear when looking at EL VMT during peak hours - Table 5 indicates that the estimated AM VMT is significantly higher (overall, AM VMT in the SB direction is more than four times higher than AM VMT for NB) in the SB direction (peak direction for AM) compared to AM VMT in the NB direction.

- The NB EL in the AM has a significantly lower value than NB GP during the same time period, indicating low utilization (for this non-peak direction). The low NB value during the AM peak can be attributed in part to the fact that only 1 NB Express Lane is available during this period.
- The SB Express Lanes during the AM peak carry a greater share of VMT than the NB lanes during the PM peak (27% vs. 23%). At least some of the difference can be attributed to the fact that 3 ELs are available for SB traffic in the AM peak, whereas only 2 ELs are available for NB traffic in the PM peak.

Vehicle Hours of Travel

Data Source

These metrics were calculated using volume, speed, travel time, and distance data. The EL data came from AMS (volume) and INRIX® (speed). The GP traffic volume data was extracted from PeMS.

Methodology and Analysis

VHT is estimated as the product of the estimated volume and travel time for each logical segment and aggregating the VHT associated with all the logical segments for the entire day.

Table 6: Peak Period VHT Estimates

	7-9AM	4-6PM
NB EL	350	1,700
NB GP	4,840	7,630
NB %VHT in EL	7%	18%
SB EL	1,700	720
SB GP	6,430	4,180
SB %VHT in EL	21%	15%

Key Findings

- The estimated vehicle hours traveled shows a similar directional pattern as the vehicle miles traveled.
- Table 6 shows the significant difference between the EL and GP VHT, driven by longer travel time on the GP during peak hours and the higher volumes associated with the GP lanes.
- A comparison of Table 5 with Table 6 shows that, for a given direction (e.g. SB) during a given time period (e.g. AM peak), the percentage of VHT attributable to the Express Lanes is lower than the percentage of VMT. This difference is attributable to the time savings provided by the Express Lanes.

Vehicle Hours of Delay

Data Source

These metrics were calculated using volume, speed, travel time, and distance data. The EL data came from AMS (volume) and INRIX® (speed). The data for GP lanes was extracted from PeMS.

Methodology and Analysis

VHD is estimated by multiplying the estimated volume for a logical segment with the estimated delay (where delay is calculated as the difference between the estimated planning travel time and the travel time if the observed speed was 60 mph), and then aggregating the VHD for all I-15 EL logical segments with delays.

Table 7: Daily VHD Estimates

	NB EL	NB GP	SB EL	SB GP
7-9AM	N/A	N/A	N/A	1,130
4-6PM	7	1,510	7	N/A

Key Findings

- Several entries ("N/A") in Table 7 indicate that there are no significant vehicle hours of delay. This means that any average delay incurred in those time periods generally did not cause the average speeds to fall below 60 mph for that specific direction. It should be noted that median speeds and travel time were used to calculate VHD.
- As Table 7 indicates, the significant delays were observed mainly in the SB GP in the AM and NB GP in the PM, which follows the directional peak period traffic pattern. SB GP lanes in the AM and NB GP lanes in the PM experience some delays in which the total VHD (in these two specific time periods in the specific peak direction) is larger than the equivalent VHD if those vehicles traveled at 60 mph.

Person-Miles Traveled on EL

Data Source

The person miles traveled is calculated using vehicle occupation data from SANDAG and the VMT data above.

Methodology and Analysis

The person miles traveled shows the directionality pattern seen in previous measures. When comparing data in

Table 8 to the vehicle miles traveled in Table 5, it shows the average vehicle occupancy is no more than 2.

Table 8: Person Miles Traveled on EL

	NB EL	SB EL
7-9AM	44,700	194,400
4-6PM	200,800	85,500

Key Findings

- The NB EL accounted for more than 200,000 person miles traveled in the PM, while the SB EL accounted for 194,000 person miles traveled in the AM.
- Overall, the PM peak period serves more person-miles in the Express Lanes than the AM peak period. This is significant, given that the NB EL during the PM peak has fewer lanes than the SB EL during the AM peak. This illustrates the potential for higher HOV usage (as documented in Figure 17) to improve the person-carrying capacity of a roadway.

5.5. Revenue and Operating Costs Overview

One of the key operating objectives of the I-15 ELs is to collect enough toll revenue to cover the cost of operating the facility. The following sections provides an overview of the following performance measures related to this operating principle:

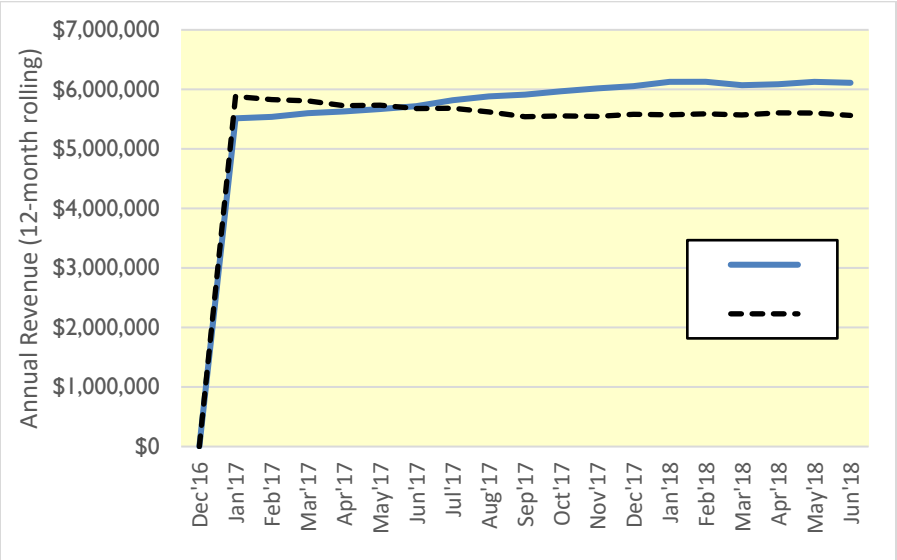
- Express Lanes Revenue

- Estimated EL Operating Costs
- Estimated EL Operating Cost Per Trip

Express Lanes Revenue

Over the 12-month period from July 2018 through June 2019, SANDAG collected $12.8 million in toll revenue from the I-15 ELs. Figure 21 illustrates how revenue has grown over the past 18 months. The chart depicts a rolling 12-month revenue total for the I-15 Express Lanes, broken out by direction.

Figure 21: Annual Revenue, 12-Month Rolling Total, Dec'17 through Jun'19

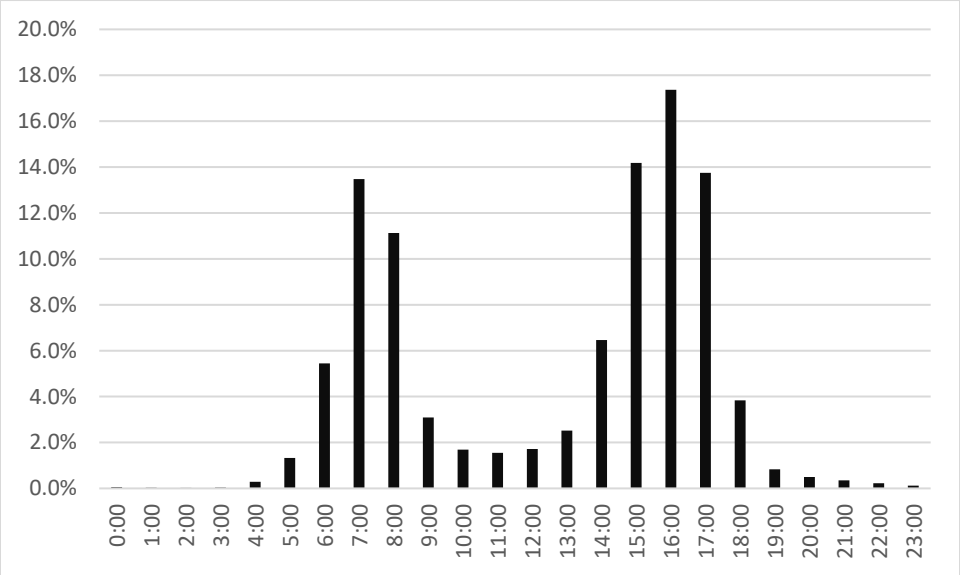


Key Findings

- From December 2017 through August 2018, the rolling 12-month revenue total (both directions combined) was consistently in the range of $11.6 to $11.7 million. Northbound revenue (averaging about $6.1 million) was consistently higher than southbound revenue (averaging just under $5.6 million).
- Since August 2018, southbound revenue has steadily climbed. In the most recent 12-month period (July 2018 through June 2019), southbound revenue totaled just under $6.5 million.
- Although northbound revenue has grown slightly in recent months, southbound revenue is now slightly outpacing northbound revenue.

The collection of revenue tends to be concentrated during peak periods. This is illustrated in Figure 22, which shows how express lane revenue varies by hour of the day.

Figure 22: Distribution of Revenue by Hour



Key Findings

- Over two-thirds of the toll revenue is collected during the five busiest hours (7am-9am and 3pm-6pm) on weekdays (Monday thru Friday).
- A greater proportion of revenue is collected during the PM peak compared to the AM peak.

Estimated EL Operating Costs

Data Source

This metric was calculated using estimated operating costs compiled from known SANDAG operating contracts.

Methodology and Analysis

The cost to operate the I-15 ELs is approximately $2.65 million per year. These costs are comprised of the following:

- $1.50 million in annual maintenance costs for the tolling equipment
- $0.50 million annual for image review services
- $0.65 million to support the barrier transfer machine, or BTM. (This reflects SANDAG's 16% share of the overall costs to move and maintain the barrier.)

Key Findings

None

Estimated EL Operating Costs Per Trip

Data Source

This metric was calculated using estimated operating costs and trip volumes. The estimated operating costs have been compiled from known SANDAG operating contracts. The trip volumes come from AMS.

The AMS recorded the following annual totals from 2018:

- Total HOV transactions = 8,701,277
- Total SOV transactions = 28,568,734
- Non-AVI reads = 106,159,460
- Total transactions (sum of HOV / SOV / Non-AVI) = 143,429,471
- Total tolled (SOV) trips = 5,901,285

By taking SOV transactions (28,568,734) and dividing by the number of tolled trips (5,901,285), we see that the average number of transactions per trip is 4.84. In other words, the average trip in the Express Lanes passes through 4.84 tolling points along the mainline.

We can use this number to therefore estimate the total number of trips (including HOV and non-AVI trips, as well as SOVs) recorded in the Express Lanes. By taking the total number of transactions (143,429,471) and dividing by the average number of transactions per trip (4.84), we can estimate that a total of 29.6 million trips (that is, 29.6 million unique entries into the Express Lanes) were served by the I-15 ELs in 2018.

It is now possible to estimate the average cost per trip served. If we take the estimated annual operating cost of $2.65 million and divide by 29.6 million annual trips, we find an estimated average cost of approximately $0.09 per trip.

Key Findings

The estimated operating cost of $0.09 per trip will be used for comparison against operational strategies under consideration.

5.6. Express Lane Trip Length

Data Sources

The estimated distances and number of trips between entry-exit points were extracted from the AMS System (specifically from the Point to Point Revenue data set).

Methodology and Analysis

The number of trips for each OD pair was coupled with the distance traveled in that OD pair to illustrate the trip length frequency, as shown in

Figure 23 and Figure 24. The data shown was extracted for September 2018 from the AMS System and averaged to give the average trip length.

The average trip length for NB traffic is 11.8 miles; SB traffic is similar with an average of 11.7 miles. A more detailed breakdown is shown in Table 9. Violations in Table 9 refer to declared occupancy violations.

Table 9: Average EL Trip Length

Vehicle Type	Northbound	Southbound
SOV	11.0	10.8
HOV	12.2	12.2
Violation	12.2	12.0

Figure 23: NB Trip Length Frequency

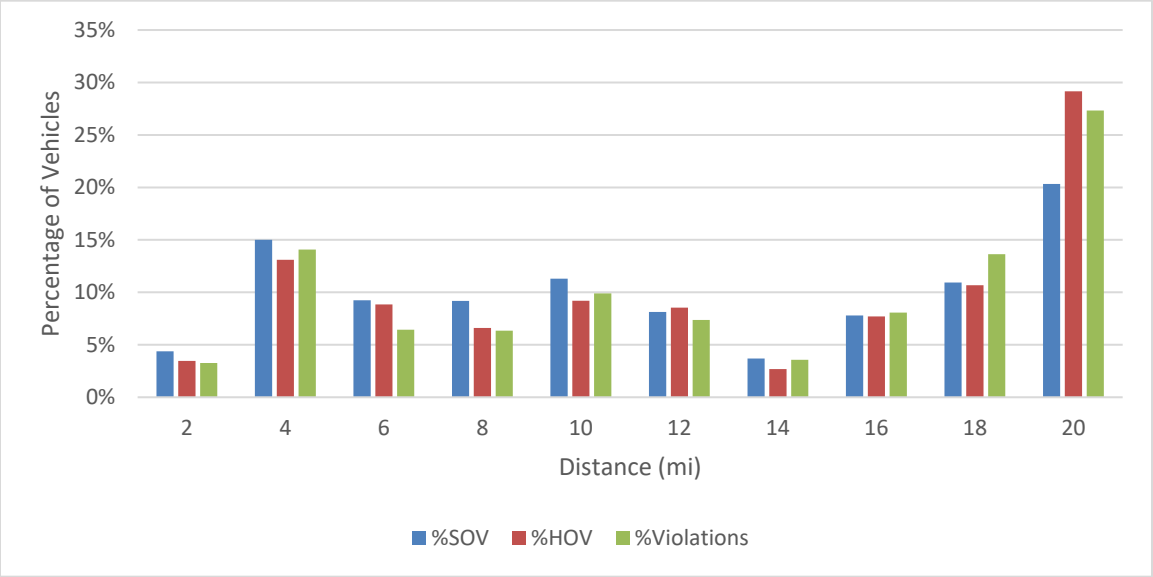
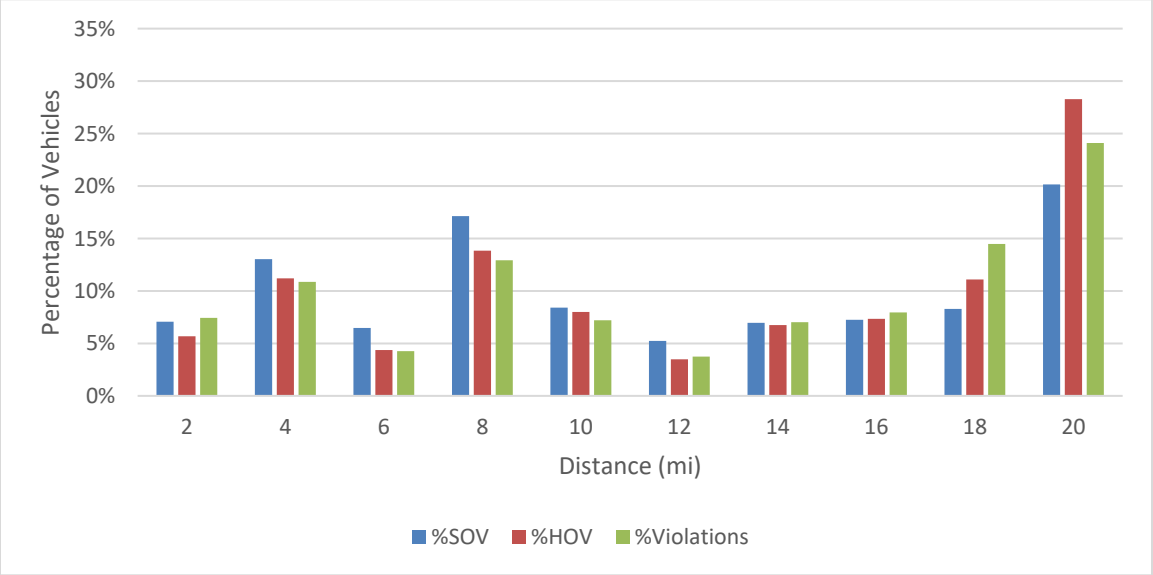


Figure 24: SB Trip Length Frequency



Key Findings

- Figure 23 and Figure 24 illustrate that a significant percentage (15% in NB and 28% in SB directions respectively) of vehicles travel nearly the entire length (the 18-20 mile range) of the corridor.
- On average, approximately 18% of EL vehicles travel 4 miles or less on the EL, 18% travel between 4 and 8 miles, 15% travel a distance of between 8 and 12 miles, and 49% travel a distance of more than

12 miles, with northbound and southbound having fairly different trip length frequency patterns for shorter and medium length trips.

5.7. FasTrak Accounts and Users

Data Sources

The number of active accounts and transponders was directly taken from the AMS system, specifically the Daily Accounts Summary report.

Methodology and Analysis

FasTrak information was extracted from AMS for the month of September in 2017 and 2018, using typical weekdays. The average weekday data from 2017 and 2019 was then summarized in Table 10, to evaluate the change in active accounts and transponders from 2017 to 2018.

Table 10: Number of Active FasTrak Accounts and Transponders

	Average 2017	Average 2018
Active Accounts	28,474	29,402
Active Transponders	42,059	44,453

Key Findings

- Table 10 shows an increase in FasTrak users from 2017 to 2018, based on AMS Daily Accounts Summary report:
  - 3.2% increase in active accounts
  - 5.7% increase in active transponders
- The average number of transponders per account also experienced a slight increase, rising from 1.48 in 2017 to 1.51 in 2018.

5.8. Travel Incidents

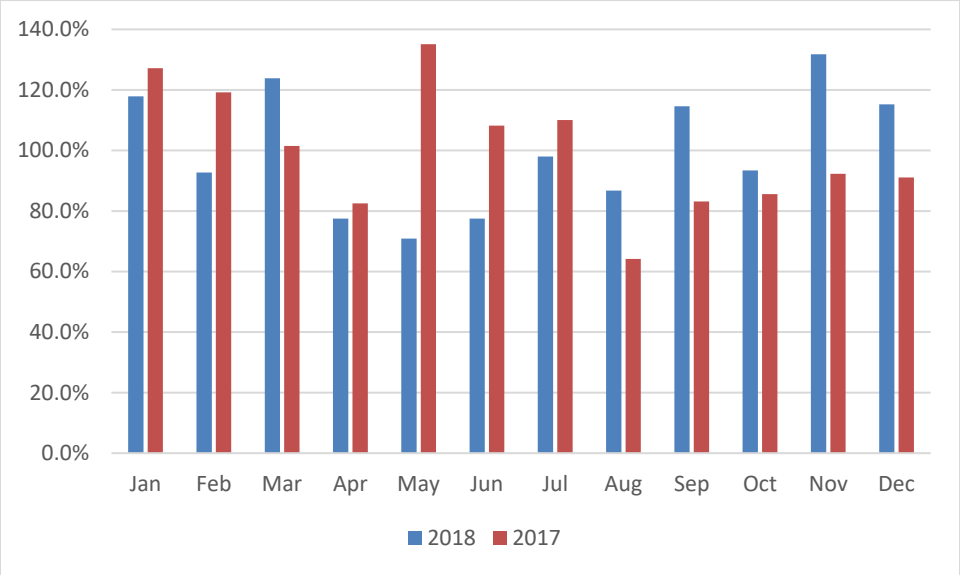
Data Sources

Detailed incident data for the I-15 corridor (EL and GP lanes combined) was available from the PeMS system, for a period of two years between January 2017 and December 2018.

Methodology and Analysis

The incident data extracted was summarized by month over the two-year period, as illustrated in Figure 25. While data was not available separately for EL and GP lanes, data was compiled for various types of incidents reported by the California Highway Patrol (CHP). The incidents vary from traffic collisions, to hit and run incidents, fires, floods, and other emergency alerts.

Figure 25: Percentage of Monthly Incident Compared to Average Month



Key Findings

- No clear pattern was identifiable comparing the 2017 and 2018 data.
- Summer months generally had a lower percentage of incidents relative to the average monthly incidents for the year.

5.9. Transit Trends for I-15 Corridor

Data Source

SANDAG

Methodology and Analysis

Average weekday transit ridership data was summarized from data provided by route for the I-15 corridor, as illustrated in Table 11 and

Figure 26. The average boardings and alightings were averaged to estimate the average weekday ridership.

Average load factor (Figure 1Figure 27) was estimated by dividing the total passenger miles for all corridor routes by the total seat-miles. It is a measure of the utilization of the available routes.

Table 11: Average Weekday Ridership for Routes in I-15 Corridor

	2016	% Change 2016 to 2017	2017	% Change 2017 to 2018	2018	% Change 2018 to 2019	2019
AM Early	734	-7%	685	3%	706	0%	708
AM Peak	3,257	-9%	2,971	-3%	2,882	1%	2,922
Midday	2,852	-5%	2,696	7%	2,883	3%	2,970
PM Late	1,010	-6%	952	-3%	926	1%	933
PM Peak	2,992	-6%	2,814	1%	2,847	-1%	2,833
Total	10,845	-7%	10,118	1%	10,243	1%	10,366

Figure 26: Total Transit Ridership for Routes in I-15 Corridor

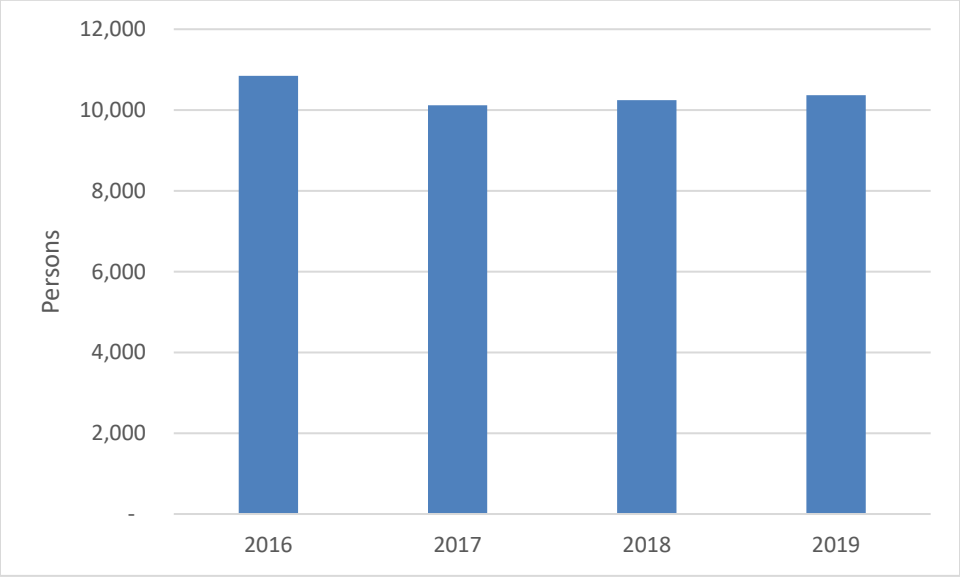
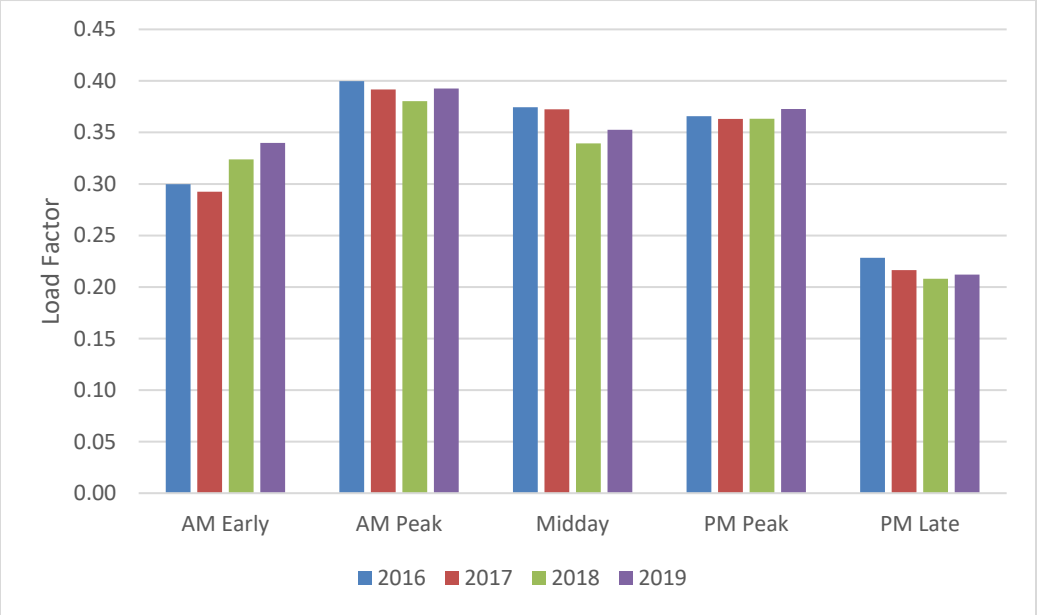


Figure 27: Average Load Factor for Average Weekday



Key Findings

- Figure 26 indicates that the number of transit passengers in the I-15 corridor has remained consistent at slightly higher than 10,000 persons on an average weekday.
- The biggest across-the-board percent change happened between 2016 and 2017. It is the most significant during the AM peak with a decrease of 9%. However, due to the generally low volumes, that percentage correlated to only 727 passengers.
- Figure 27 illustrates that the load factor was lowest during the late PM period (6:00pm - 11:59pm), and highest during the AM peak period (6:00am - 8:59am), as might be expected.
- Generally during the AM peak, midday, and PM peak the load factor remains somewhat constant. This can be an indicator that there is a consistent level of supply and demand throughout that period of the day.

6. Summary of Performance Measures

A summary of the various performance measures including a single value (or a handful of locations) for each measure if included in Table 12. These values for several of the performance measure shown will serve as a baseline for existing conditions to compare against in Task 3.

Table 12: List of Baseline Performance Measures

		Via Rancho Pkwy	Carmel Mtn Rd	Miramar Way	Via Rancho Pkwy	Carmel Mtn Rd	Miramar Way	
Goals and Objectives	**Related Performance Measures**	Peak Period Northern	Peak Period Central	Peak Period Southern	Daily Northern	Daily Central	Daily Southern	Corridor Wide
Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers with discounted tolls	• % of EL vehicles traveling as SOVs				45	53	50	
	• % of EL vehicles carrying 2 people (HOV2)				46	43	44	
	• % of EL people traveling as HOV3+				17	8	12	
	• Transit ridership							10,243
Generate enough revenue to sustain I-15 EL ops	• Express Lanes Revenue							11.6
	• Estimated Express Lanes Operating Costs							2.65
	• Estimated Net Revenue (revenue less op costs)							8.95
Minimize O&M costs	• Annual average cost incurred per trip served							$0.09
Optimize and maintain I-15 Express Lane trip reliability	• EL Travel Times (daily and peak period)							19 min
	• EL Speeds	73	71	70				
	• EL 90th percentile travel times							28 min
Reduce I-15 corridor (GP and EL) person and/or vehicle delay	• EL vehicle-hours of travel (VHT)							2050 (AM) & 2420 (PM)
	• EL vehicle-hours of delay (VHD)							N/A (AM) & 14 (PM)
	• GP Travel Times (daily and peak period)							28 min
	• GP Speeds	54	50	51				
	• GP VHT							11,270 (AM) & 11,810 (PM)
	• GP VHD							1130 (AM) & 1150 (PM)
Improve I-15 corridor (GP and EL) throughput	• EL vehicle throughput				46,103	45,604	46,510	
	• EL vehicle VMT							145,300 (AM) & 164,600 (PM)
	• EL person-miles traveled							239,100 (AM) & 286,300 (PM)
	• GP vehicle throughput				211,475	225,994	260,379	
	• GP VMT							629,300 (AM) & 638,700 (PM)
	• # of FasTrak transponders and active accounts							29,402 accounts & 44,453 transponders
Improve efficiency in the Express Lanes	• EL person throughput				79,758	78,895	79,997	
	• Average FasTrak user trip length							11.75
	• Express Lanes violation rates							25%
	• Frequency and Duration of HOV-Only Events							33 occurrences & 68 min/occurrence
Improve transit service performance	• Transit on-time performance							
	• Transit peak load factor							0.39
Reduce incidents and travel delays	• Number of travel incidents per year from CHP							151

APPENDIX E: EXISTING OPERATIONAL AND PERFORMANCE CONDITIONS REPORT

I-15 Express Lanes Operational Study
Contract # 5004863 – Task Order No. 3

Existing Operational and Performance Conditions Report
Version 2.0

October 21, 2019

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1. Introduction

The I-15 corridor is the primary inland north-south trunk line that connects and serves interregional travelers between Riverside County and downtown San Diego. It also is part of a major interregional goods movement corridor, connecting Mexico with Riverside and San Bernardino counties, as well as Las Vegas, Nevada.

The San Diego Association of Governments (SANDAG), in partnership with the California Department of Transportation (Caltrans), operates and maintains the I-15 corridor. SANDAG and Caltrans are working cooperatively to establish and maintain performance parameters to help guide the day-to-day operations of the I-15 Express Lanes (EL) to ensure the I-15 corridor continues to perform as designed. In 2015, SANDAG, Caltrans, and the San Diego Metropolitan Transit System (MTS) established the I-15 Corridor Management Team (CMT) to undertake a number of activities to build consensus, improve communications, and improve procedural and business practices. The ultimate purpose of these activities is to more effectively manage and operate the I-15 corridor as a unified network.

This report helps advance the CMT's efforts to identify and assess operational strategies that help overall I-15 corridor operations by employing a performance based approach. This report assesses the existing operational environment which will be used as a baseline in future study of operational system improvements for the I-15 EL to better handle the current and future transportation demand along the I-15 corridor.

2. Purpose

The purpose of this report is to provide an overview of the existing operational and performance conditions of the I-15 corridor. The report will summarize the key information findings that were documented in various technical memoranda developed under Task 2 of the I-15 Express Lanes Operational Study. Study details can be reviewed in the attached technical memoranda.

The report is structured in the following manner:

- Section 2 provides an overview of the I-15 Express Lanes Operational Study and the work performed under Task 2.
- Section 3 discusses how the I-15 Express Lanes are operated today. This discussion will highlight some of the key business rules that currently govern operations on the facility.
- Section 4 discusses the I-15 Corridor Management Team's vision, goals, and objectives for the I-15 corridor.
- Section 5 provides a summary of the performance measures selected for this study.
- Section 6 summarizes the results and key findings of the existing operational performance analysis.
- Section 0 discusses how the results of Task 2 will be used to inform analysis of operational strategies.

3. I-15 Existing Operating Environment

The I-15 ELs operate 24/7 as a continuous 20-mile corridor between State Route (SR) 78 and SR 163. The I-15 ELs provide 4 lanes of travel throughout the 20-mile length of the facility. The southern 16-mile section is reversible and separated by moveable concrete barrier which allows for the ELs to be configured in multiple

lane combinations to meet travel demand. Travel demand is controlled using a dynamic pricing algorithm that continually updates the price for SOVs to access the ELs.

SANDAG has established several rules that establish the eligibility and payment requirements for the I-15 EL. The following rules have been found to be key parameters impacting SANDAG's ability to control EL operations:

- All single-occupant vehicles (or "SOVs") must have a transponder and are responsible for paying the posted toll.
- Vehicles that have 2 or more occupants (also known as "high-occupancy vehicles" or "HOVs") can use the ELs for free without needing a transponder. Clean Air Vehicles (CAVs) can also use the ELs for free, regardless of occupancy.
- The maximum price to use the ELs is limited to $1 per mile and a maximum of $8 per trip.
- When two conditions are simultaneously met for a particular access point—namely, when the maximum $1 per-mile rate has been exceeded, and when the lanes are operating at Level of Service "D" or below—then the lanes transition to "HOV ONLY" mode. This mode prohibits SOVs from access the ELs.

A complete description of the I-15 EL existing operational environment can be found in the attached *Existing Operational Environment Assessment Technical Memorandum*.

4. I-15 CMT Vision

A CMT Visioneering Workshop was held on June 28, 2019 to define the CMT's vision, objectives, and goals for the I-15 corridor. The purpose of this workshop was to create a foundation that all subsequent work in this study will built upon. This section summarizes the outcomes of this workshop. Detailed discussion focused on the vision, goals and objectives for this corridor can be found in the attached *I-15 Express Lanes Corridor Management Team Vision Technical Memorandum*.

<u>I-15 Express Lanes Vision Statement</u>

Provide a world class transportation facility that:

- Provides safe, reliable, predictable commute for I-15 Express Lanes customers;
- Provides easy to use travel options without barriers that meets the needs of today while also sustaining future growth and evolution in travel options;
- Has regionally consistent business rules and operating policies;
- Is aligned with Caltrans' & SANDAG's Mission and Vision;
- Strengthens successful partnerships with SANDAG, Caltrans, MTS and other stakeholders;
- Is a model for other Express Lanes corridors in the region; and
- Complements I-15 General Purpose Lane operations.

<u>Goals</u>

- Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls.
- Generate sufficient revenue to sustain I-15 Express Lanes operations.

- Inform public of travel options, including SOV, HOV, and transit, and provide knowledge for customers to use making travel choices.
- Provide equal access to all customers.
- Equally enforce the toll policy across all travel choices.
- Minimize maintenance and operations costs.
- Enhance corridor management and operations.

Objectives

- Optimize and maintain I-15 Express Lane trip reliability.
- Reduce I-15 corridor (GP and EL) person and/or vehicle delay.
- Improve I-15 corridor (GP and EL) person and/or vehicle throughput.
- Improve efficiency in the Express Lanes.
- Improve transit service performance.
- Reduce incidents and associated travel delays.

5. I-15 Performance Measures

Based on the agreed to I-15 Vision Statement and these Goals and Objectives, a comprehensive list of performance measures was developed for the Project. At least one performance measure was associated to each of the I-15 Express Lanes Goals and Objectives.

Table 1 presents the performance measures selected for the study and shows how each performance measure supports the I-15 goals and objectives. Detailed discussion focused on each performance measure, including the calculation methodology, can be found in the attached *I-15 Express Lanes Operational Study Performance Measures Technical Memorandum*.

Goals & Objectives		Related Performance Measures
Goals	Balance capacity & demand to serve customers who pay tolls as well as carpoolers & transit customers who are offered discounted tolls	• % of EL vehicles traveling as SOVs • % of EL vehicles carrying 2 people (HOV2) • % of EL people traveling as HOV3+ • Transit ridership
	Generate sufficient revenue to sustain I-15 Express Lanes operations	• Express Lanes Revenue • Estimated Express Lanes Operating Costs • Estimated Net Revenue (revenue less operating costs)
	Minimize O&M costs	• Annual average cost incurred per trip served
Objectives	Optimize & maintain I-15 Express Lane trip reliability	• EL Travel Times (daily & peak period) • EL Speeds • EL 90th percentile travel times
	Reduce I-15 corridor (GP and EL) person and/or vehicle delay	• EL vehicle-hours of travel (VHT) • EL vehicle-hours of delay (VHD) • GP Travel Times (daily & peak period) • GP Speeds • GP VHT

		• GP VHD
	Improve I-15 corridor (GP and EL) person and/or vehicle throughput	• EL vehicle throughput • EL VMT • EL person-miles traveled • GP vehicle throughput • GP VMT • # of FasTrak transponders and active accounts
	Improve efficiency in the Express Lanes	• EL person throughput • Average FasTrak user trip length • Express Lanes violation rates • Frequency and Duration of HOV ONLY events
	Improve transit service performance	• Transit on-time performance • Transit peak load factor
	Reduce incidents and travel delays	• Number of travel incidents per year from CHP

6. I-15 Existing Operational Performance Analysis

The *Existing Operational and Performance Conditions Report* provides a summary of the existing operational performance of the I-15 Express Lanes corridor. This section provides an overview of those trends and also includes further analysis of the possible causes or explanations for some of the observed trends.

Data Collection

Data from several different sources were extracted and processed for developing various performance measures. These data sources included (but are not limited to) the following:

1. Account Management System (AMS)
2. Caltrans Performance Measurement System (PeMS)
3. National Performance Management Research Data Set (NPMRDS)
4. Transit data from SANDAG and MTS
5. Violation data

Detailed information and background on each of these data sources is provided in the *Existing Operational and Performance Conditions Report.*

Analysis Overview

Hourly and monthly traffic data from AMS (for the ELs) and PeMS (for the GP lanes) was summarized to identify variations in traffic demand from 2017 through early 2019. Similarly, median and planning time speeds were analyzed using speed heat maps for all recorded EL trips in the datasets in 5-minute increments by direction. Travel time reliability was analyzed by estimating the range of observed travel times (the lower bound and upper bound were used to determine the travel time for 10 percent and 90 percent of vehicles, respectively, that experience a specific travel time or faster) for a through trip on the ELs for an average weekday. These were used to illustrate the degree of consistency and travel time dependability of the ELs.

Vehicle occupancy survey data provided by SANDAG was used to estimate the HOV/SOV split on the ELs, to estimate the percentage of persons in HOVs and to develop estimates for vehicle miles of travel (VMT) and vehicle hours of delay (VHD) for ELs in the peak periods. Estimated revenue, EL operating costs and the average cost per EL trip were summarized using data provided by SANDAG (and from the AMS). Based on data provided by SANDAG and MTS, violation rates and transit parameters including ridership and average peak load factors for routes using the I-15 corridor were estimated. Finally, the trends for average typical EL trip lengths and frequency of occurrence of HOV-only mode were analyzed.

Key Findings

This section presents some major themes emerging from our detailed analysis of the various performance measures.

Theme 1: *Southbound ELs are rarely congested in the AM peak period, resulting in high throughput and reliable travel times*.

The following factors may contribute to this:

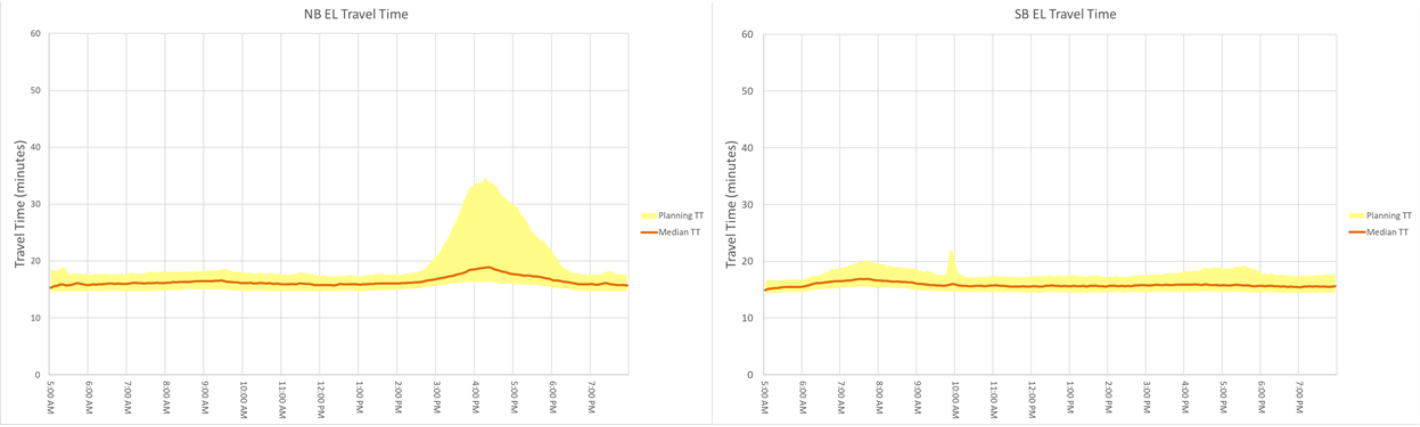
- Additional capacity (3 lanes) is provided in the southbound direction during the AM peak travel period. This additional southbound capacity is sufficient to accommodate the existing demand in the AM peak period. While HOV violators can strain the capacity of the ELs, this issue is not evident because the additional capacity in the southbound direction in the AM more than compensates for any unauthorized usage related to HOV violators.
- The percentage of SOV customers is significant higher in the southbound direction. This suggests that paying (SOV) customers are aware of the faster EL travel times (and the high travel time reliability compared to GP lanes) and understand the value of a reliable trip (related to the typical travel time savings).
- Southbound hourly traffic (during the AM peak period) and overall southbound revenue has significantly increased since June 2018, despite the fact that traffic levels are still well below the maximum available southbound AM capacity. This suggests that there is still some available capacity for traffic to grow.
- The violations trend shows that southbound AM generally has a higher violation rate compared to the complementary northbound movement in the PM.

Theme 2: *Northbound EL's are frequently congested during the PM peak, resulting in low throughput and unreliable travel times*.

The following factors may contribute to this:

- In contrast to the southbound direction during the AM peak period, additional northbound capacity is **not** provided during the PM peak travel period (i.e. by reconfiguring to a 3NB + 1 SB layout). As a result, demand at some locations exceeds the available northbound capacity in the PM peak. This is evidenced by the lack of growth in the northbound direction during the PM peak.
- Violations trends: In the northbound direction during the PM peak period (peak direction for PM), the violation rate is relatively high (at some locations - at Carmel Mountain Road, for example - comparable to the rate observed during the southbound AM peak). The overall trend for nearly all available locations (for which violation data is available) has been toward increasing violation rates since mid-2018.
- The HOV2 and HOV3+ percentage was higher in the northbound during the PM period compared to the southbound direction in the AM period. This is perhaps due to the available northbound PM capacity being taken by the HOVs, with the result being that SOVs are not willing to pay for an unreliable travel time trip (because the NB EL in the PM is at capacity).
- Delays: Generally, the planning travel time for northbound travel during the PM peak period is more than 50 percent higher (i.e., slower) than the corresponding median travel time, as illustrated in Figure 1. This is further corroborated by the planning speeds which indicate that the EL northbound traffic experiences median speeds near 45 mph but can experience significantly lower planning time speeds, with 10% of vehicles experiencing speeds as low as 25 to 30 mph.

Figure 1: Travel Time



Theme 3: *Occurrences of "HOV Only" in the northbound direction have significantly increased since June 2018*

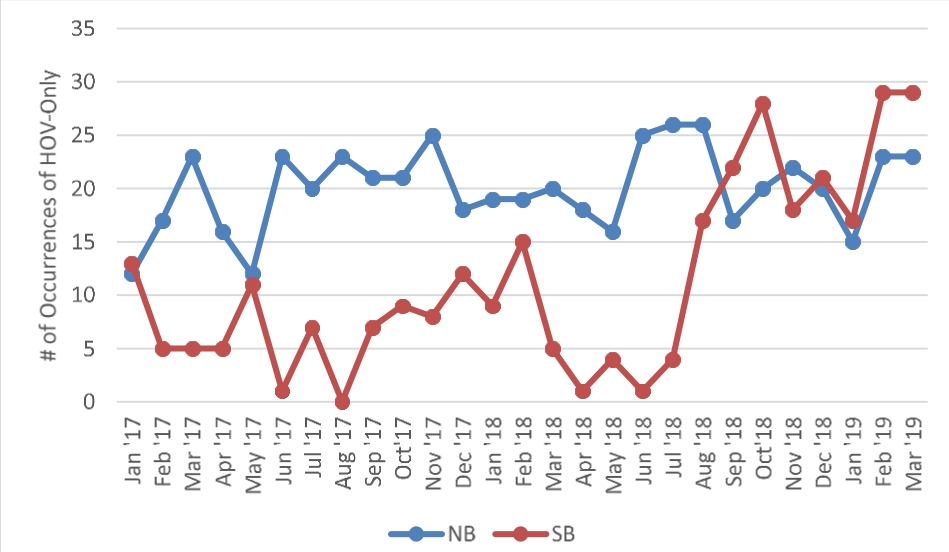
This theme is illustrated in Figure 2. This has had the following causes and impacts:

- The fact that the northbound ELs are reaching their capacity during PM peak periods causes the triggering of the HOV only mode more frequently. The existing Dynamic Pricing Algorithm is based on the density detected at key locations. As the density increases (and resulting LOS worsens), the rate per mile is increased to try and reduce the demand. During the peak periods—in particular, for the

northbound direction in the PM peak period—the pricing algorithm is not able to manage the demand. This is a function of a relatively low per-mile limit ($1.00 per mile) and a relatively low threshold for being considered "congested" (LOS D). The result is a frequent triggering of the HOV Only mode.

- Once any specific access point goes to HOV Only, the algorithm also triggers all upstream locations to become HOV Only. The HOV Only mode at any given entry point only stops once all downstream segments have acceptable densities. This degree of sensitivity of the pricing algorithm (and the HOV Only triggering) results in frequent and extended durations of HOV Only mode. This is particularly true in the northbound direction during the PM peak.
- One likely effect of the HOV Only mode is that the percentage of HOVs in the northbound vehicles in the PM peak becomes higher (compared to southbound EL vehicles in the AM), effectively reducing the ability of SOVs to access the northbound lanes.

Figure 2: Frequency of HOV-Only



Theme 4: *Violations Rates have steadily increased since 2014*.

This has had the following causes and impacts:

- Violations are common because violation enforcement is difficult in the I-15 EL corridor.
- Violators are consuming available capacity on a facility that is already at or near capacity in the northbound direction during the PM peak period. This results in periods of congestion and unreliable travel times.
- The extent of violations has a negative impact on revenue. This is evidenced by the fact that, during peak periods, the violation rate in the peak direction is nearly twice as high as the violation rate in the off-peak direction. In other words, violations are greatest at times when the demand (and the corresponding toll rate and revenue potential) is at its peak.

Theme 5: *Vehicle occupancy remains low (at most locations, SOV comprise more than 40% of vehicles, and less than 10% of vehicles are HOV 3+ during the peak periods in the peak direction)*.

This has had the following cause and impact:

- For the peak periods (particularly in peak direction during the peak period, i.e., SB AM and NB PM), the SOV percentage is significant. SOVs make up 60% or more of traffic in the southbound direction during the AM peak period, and they make up 40% or more of traffic in the northbound direction during the PM peak period. Overall, this suggests that there is a lot of potential of improving person throughput by increasing the average vehicle occupancy.
- The effect of low vehicle occupancy (average vehicle occupancy is 1.7 persons per vehicle) is that the person throughput is lower, which reduces the person-carrying efficiency of the lanes.

7. Next Steps

Task 2 has focused on three key topics:

- Providing an understanding of the manner in which the I-15 Express Lanes are currently operated, focusing on key business rules and operating approaches that help shape current operations.
- Clearly identifying the goals and objectives of the I-15 Express Lanes and the broader corridor in which they operate, as established by the Corridor Management Team.
- Evaluating the extent to which the I-15 Express Lanes currently meet these goals and objectives.

The analysis has identified some areas in which current operations fall short of the CMT's goals and objectives. The next step in this study is to take a detailed look at specific changes that SANDAG could implement to address these deficiencies. Some possible changes include the following:

- Require all I-15 Express Lanes users to have a transponder
- Modify the HOV requirements to HOV3+
- Raise the per-trip maximum toll, currently set at $8 per trip
- Raise the per-mile maximum toll rate per mile, currently set at $1 per mile
- Consider how to selectively employ a 3NB + 1SB configuration during period of peak northbound travel demand
- Modify the thresholds for conversion to HOV Only mode

The next phase of the analysis will begin by coordinating with the Corridor Management Team to identify a set of immediate strategies to consider for assessment. These strategies will then be evaluated in terms of their potential for enhancing operations and facilitating the attainment of the goals and objectives identified in Section 4. Additionally, these strategies will be considered in light of other important dimensions related to deployment, such as:

- Implementation phasing and timing
- Order-of-magnitude cost estimates
- Potential impact on tolling systems
- Roadway right-of-way constraints
- Consistency with regional and statewide transportation initiatives

- Consistency with statewide policies relating to express lanes enforcement and operational requirements

8. Attachments

Existing Operational Environment Assessment Technical Memorandum - 8/29/19

I-15 Express Lanes Corridor Management Team Vision Technical Memorandum - 8/29/19

I-15 Express Lanes Operational Study Performance Measures Technical Memorandum - 8/29/19

Existing Operational Performance Analysis Technical Memorandum - 10/21/19

APPENDIX F: OPERATIONAL STRATEGY PERFORMANCE ANALYSIS TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, Todd Pendleton, HNTB

Date: November 7, 2019

Subject: Operational Strategy Performance Analysis Technical Memorandum

Purpose

The purpose of this memorandum is to summarize the I-15 Express Lanes operational strategy performance analysis conducted under Task 3. The memo documents the performance impacts associated with two key operational strategies believed to have potential to improve existing operational deficiencies documented during Task 2.

This technical memo is a preliminary assessment which will be review with the I-15 Corridor Management Team (CMT). Following review with CMT, the analysis will be finalized and documented in the *Operational Strategy Performance Findings Technical Memorandum* to be delivered upon conclusion of Task 3.

Performance Measure Summary

The "existing conditions" analysis completed under Task 2 defined a series of performance measures used to evaluate the operation of the I-15 Express Lanes. Task 3 evaluates the likely impact of two key operational strategies on these performance measures. These two strategies include:

- **Strategy #1 – Transponder for All**. This strategy requires all users of the Express Lanes to have a transponder, regardless of the number of occupants.
- **Strategy #2 – Change HOV Eligibility**. This strategy increases the required number of occupants (for toll-free travel) from HOV2+ to HOV3+. (NOTE: This strategy was evaluated independent of the requirement of a transponder.)

Methods and Assumptions

The following bullets summarize the key elements of HNTB's methodology as well as the critical assumptions underlying our analysis.

- The analysis was largely informed by a detailed review of the I-25 and US-36 Express Lanes in greater Denver. The I-25 Express Lanes opened in June 2006 as a six-mile, two-lane reversible facility.
    - Initially, HOV2+ vehicles could use the I-25 Express Lanes without a transponder. The requirement for HOVs to have a transponder was added in July 2015, and it resulted in a significant change in traffic composition. Over the course of 12 months, this change (a) reduced the total volume of Express Lane usage by 18%, (b) increased the market share of SOVs by about 16%, and (c) increased revenue by roughly 45%.
    - The Express Lanes on both I-25 and US-36 were converted from HOV2+ to HOV3+ in January 2017. This resulted in an increase in the number of HOV3+ vehicles but a decline in the

overall percentage of vehicles classified as "HOVs." The change also provided a boost to revenue, since the overall share of drivers that paid to use the Express Lanes grew by over 11%.

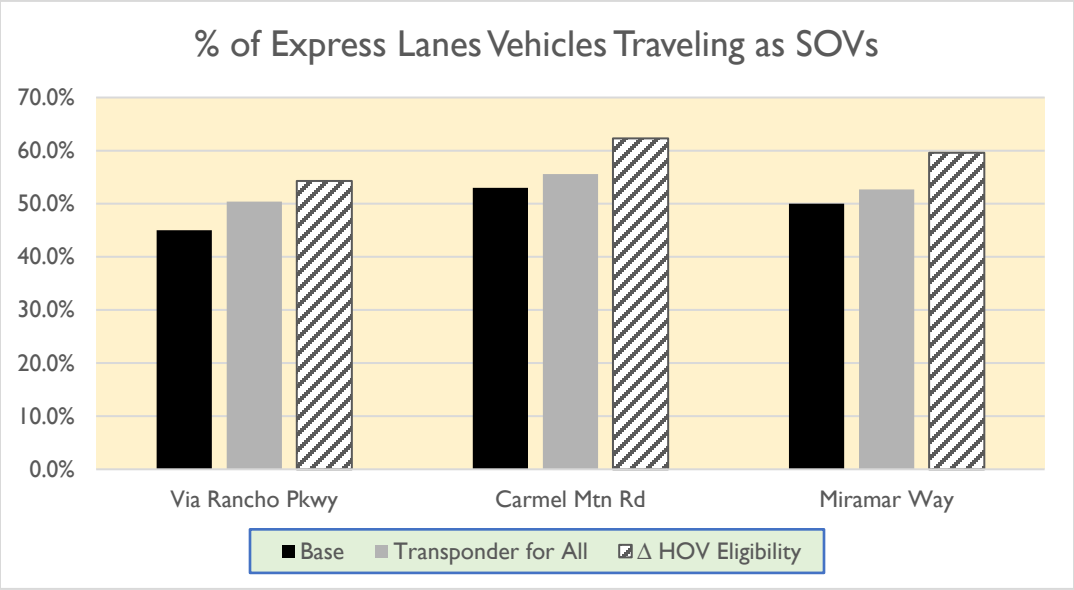
- HNTB assumed that today's violators—which currently comprise 15% to 27% of the users of the Express Lanes—can be divided into "Group 1" and "Group 2" violators. We assumed that Group 1 (the "Hard Violators") make up 10% of the EL users; they will continue to violate regardless of any policy changes. The remainder are assumed to belong to Group 2, whose behavior is subject to change based on the details of the policy being implemented.
- Under current policy, HOVs are not required to have a transponder. However, for analysis purposes, HNTB assumed that 20% of EL users have a switchable transponder (acquired from other agencies) that are toggled to HOV mode when using the Express Lanes.
- The following assumptions governed the impact of the "Transponder for All" policy:
    - Of the Group 2 violators, 50% acquire a transponder and convert to paying SOV customers. The other 50% shift to the GP lanes.
    - Of the current HOV travelers that do not have a transponder:
        - 60% acquire a transponder and continue to use the EL
        - 30% do not acquire a transponder and shift to the GP lanes instead
        - 10% do not acquire a transponder, but continue to use the EL as violators
- The following assumptions governed the impact of the "Δ HOV Eligibility" policy:
    - This policy has no impact on current HOV3+ users
    - Of the current HOV2 users of the Express Lanes that already have a transponder:
        - 55% continue to use the EL as paying customers
        - 25% shift to the GP lanes to avoid the new toll
        - 15% add a passenger and become HOV3+ vehicles
        - 5% become violators
    - Of the current HOV2 users of the Express Lanes that do not have a transponder:
        - 45% acquire a transponder and continue to use the EL as paying customers
        - 30% shift to the GP lanes to avoid the new toll
        - 25% become violators
- The high-level revenue estimates contained in this report assume that revenue is directly related to the number of paying vehicles. So, if a policy is projected to increase the number of paying vehicles by 10%, then the revenue will also be projected to increase by 10%.
- For "person throughput" calculations, it is assumed that HOV3+ vehicles carry an average of 3.1 occupants per vehicle.
- HNTB translated volume changes into speed changes via the use of speed-flow curves developed for both the general purpose (GP) lanes as well as the Express Lanes (EL). The speed-flow curves were developed by HNTB through a detailed examination of speeds and volumes captured during peak periods. The GP lane data was gathered via Caltrans' Performance Monitoring System (PeMS), while the EL data was gathered from the toll system.

The remainder of the report will review the impact of the aforementioned two operational strategies on 11 different performance measures identified during Task 2.

Analysis Results

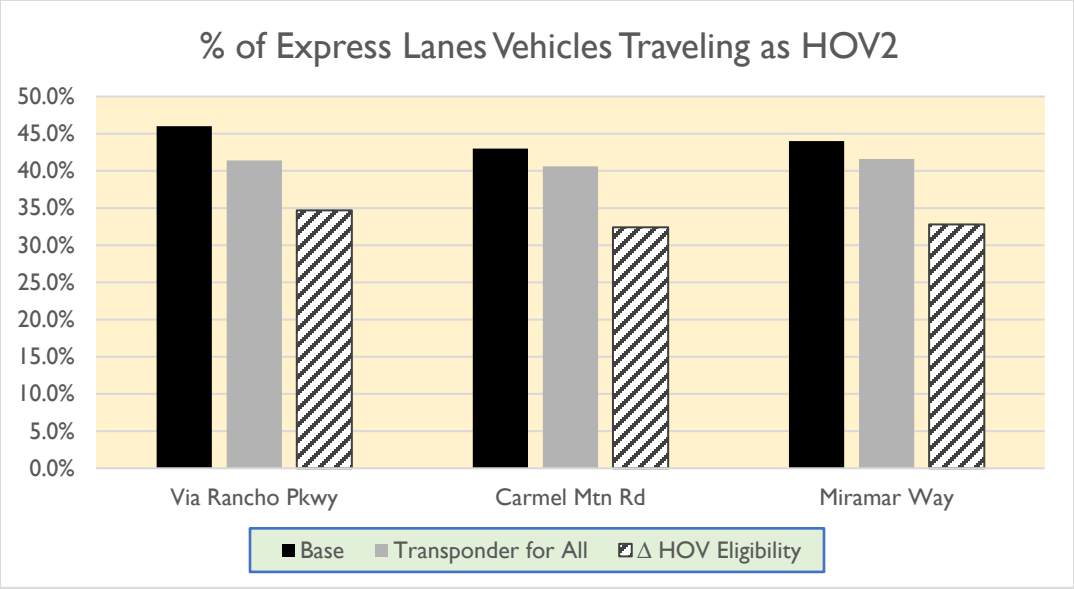
The graphics that follow summarize the key results of HNTB's analysis. In most cases, the graphics are divided into three groups, with each group representing a geographic cross-section of the existing I-15 Express Lanes. For example, the graphic for Performance Measure #1 illustrates the projected market share of SOVs at three locations—Via Rancho Parkway (northern portion of the EL), Carmel Mountain Rd. (central portion), and Miramar Way (southern portion).

Performance Measure #1 – Percentage of Express Lane Vehicles Traveling as SOVs



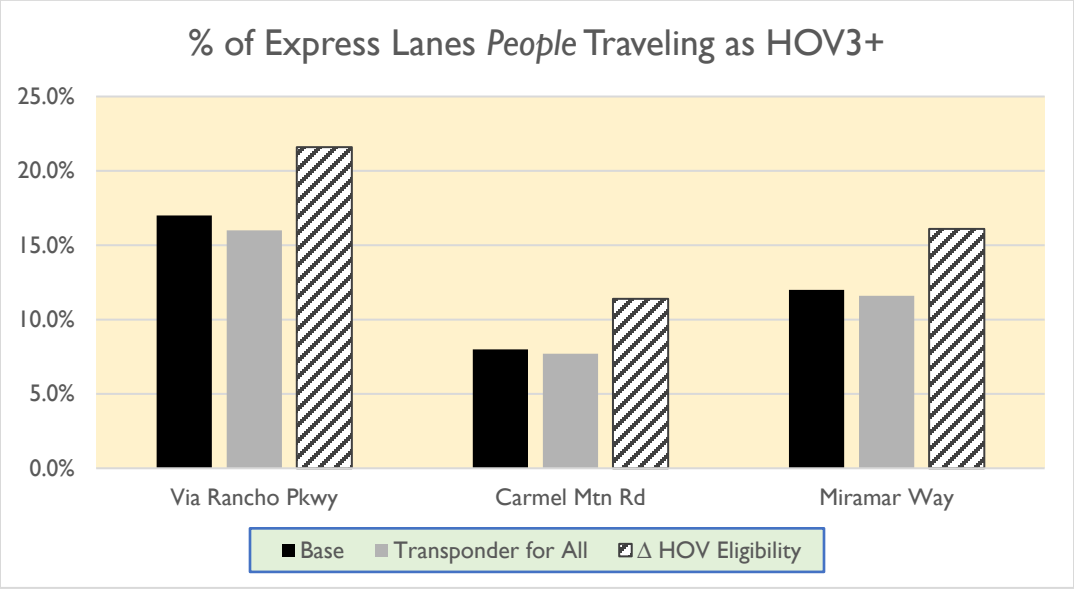
- Both strategies are expected to increase the percentage of vehicles that travel as SOVs.
- The reason is that both strategies add requirements for free usage of the Express Lanes. The "Transponder for All" strategy adds requirements by mandating that all high-occupancy vehicles to acquire a transponder. The "Δ HOV Eligibility" strategy adds requirements by mandating that all high-occupancy vehicles have 3 or more occupants to qualify for free travel.
- In short, these strategies make it slightly harder for drivers that currently use the lanes for free to continue doing so. As a result, it is expected that some existing HOV vehicles will divert to the GP lanes, resulting in a greater proportion of the vehicles are expected to be SOVs.

Performance Measure #2 – Percentage of Express Lane Vehicles Carrying 2 People



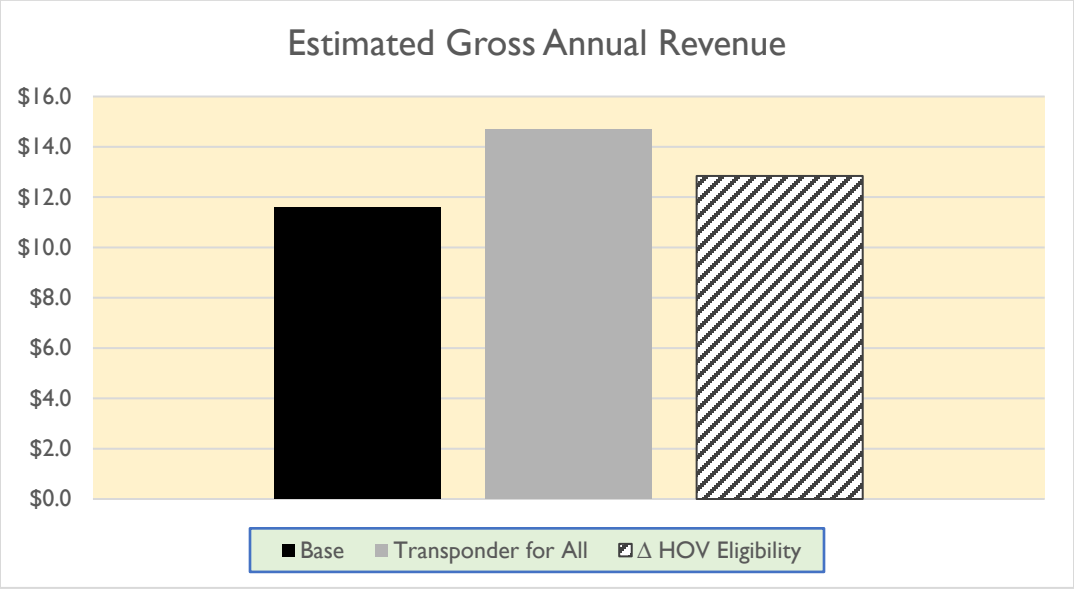
- This is a mirror image of Performance Measure #1. In other words, the *increase* in the percentage of SOVs is reflected by a *decrease* in the percentage of HOV2 vehicles.
- In existing conditions, HOV2 vehicles may travel for free with no transponder. Both above-listed strategies change this. The "Transponder for All" strategy adds a requirement to acquire a transponder to travel for free; the "Δ HOV Eligibility" strategy adds a requirement to add a passenger to travel for free.
- Since it is generally more difficult to add a passenger than to acquire a transponder, the "Δ HOV Eligibility" strategy has a slightly greater impact on reducing the share of HOV2 vehicles.

Performance Measure #3 – Percentage of People in Express Lanes Traveling as HOV3+



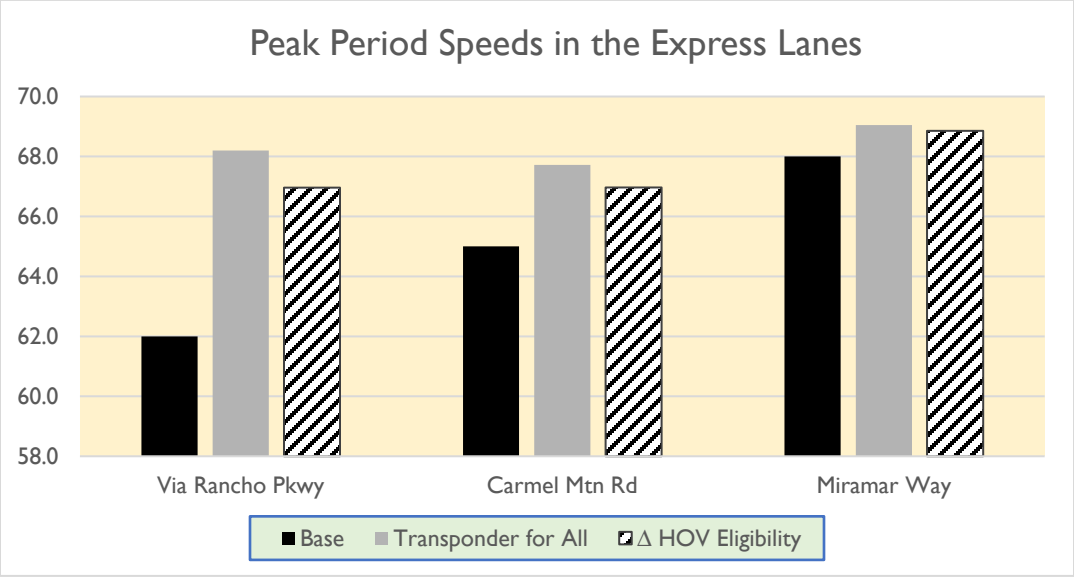
- The "Transponder for All" strategy results in a decline in the share of people traveling as HOV3+ vehicles, since—as noted earlier—the addition of a new requirement for Express Lane usage yields a slight decline in the number of HOV3+ vehicles.
- The "Δ HOV Eligibility" strategy results in an *increase* in the share of people traveling as HOV3+ vehicles. This strategy does not impact existing HOV3+ users, but it provides a significant cost-saving incentive for other users (both SOVs and HOV2) to add passengers and become HOV3+ vehicles. As a result, the number (and market share) of HOV3+ *vehicles* grows, thus increasing the share of *people* traveling in HOV3+ vehicles.

Performance Measure #4 – Express Lanes Annual Revenue



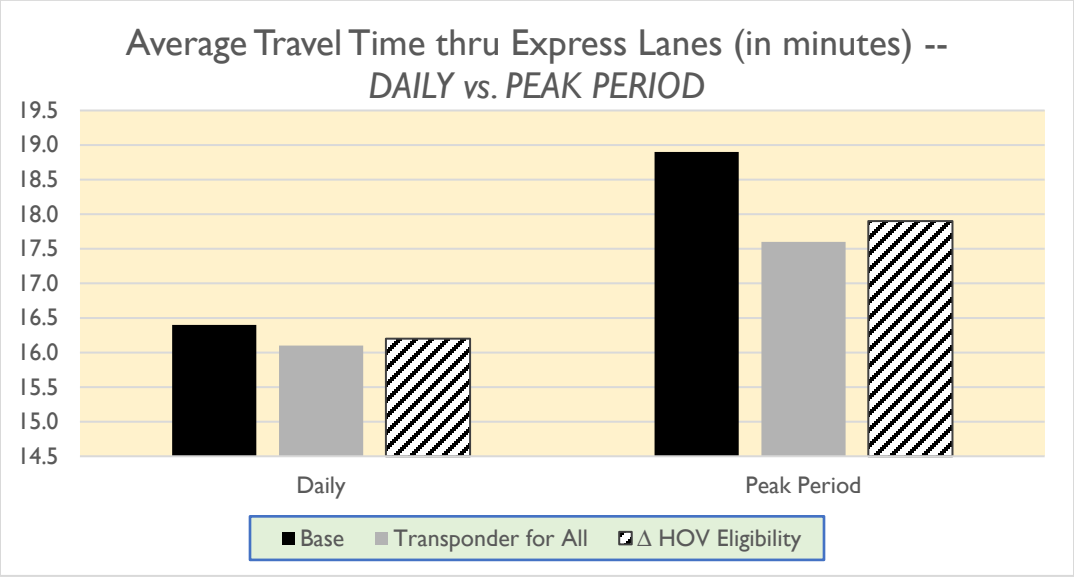
- HNTB's revenue analysis made a high-level assumption that revenue is directly related to the number of toll-paying vehicles.
- Experience has shown that introducing a transponder requirement will tend to encourage some existing violators to acquire transponders and become paying customers. For this reason, the number of paying users of the Express Lanes tends to increase, yielding more revenue.
- Increasing the HOV requirement (from HOV2+ to HOV3+) also tends to increase the number of paying customers, since the HOV2s who choose to continue to use the Express Lanes are required to pay a toll.
- It is interesting to note that the data suggests that incorporating a transponder requirement has a more positive impact on gross revenue than simply changing the HOV requirements.

Performance Measure #5 – Express Lanes Speeds (peak period)



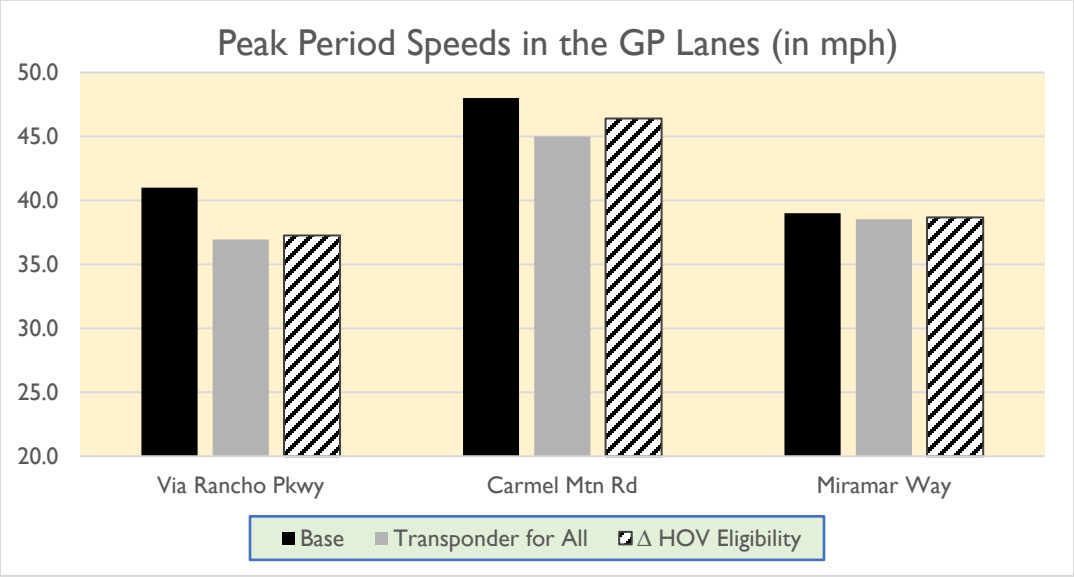
- Both strategies have a positive impact on improving peak-period speeds in the Express Lanes.
- Although these strategies increase the number of *paying* users in the Express Lanes, they reduce the number of *total* users. This reduction takes place as a result of adding requirements for toll-free use of the Express Lanes.
- This reduction in overall volume helps reduce peak-period congestion and therefore increase speeds.

Performance Measure #6 – Average Travel Time thru Express Lanes (daily & peak period)



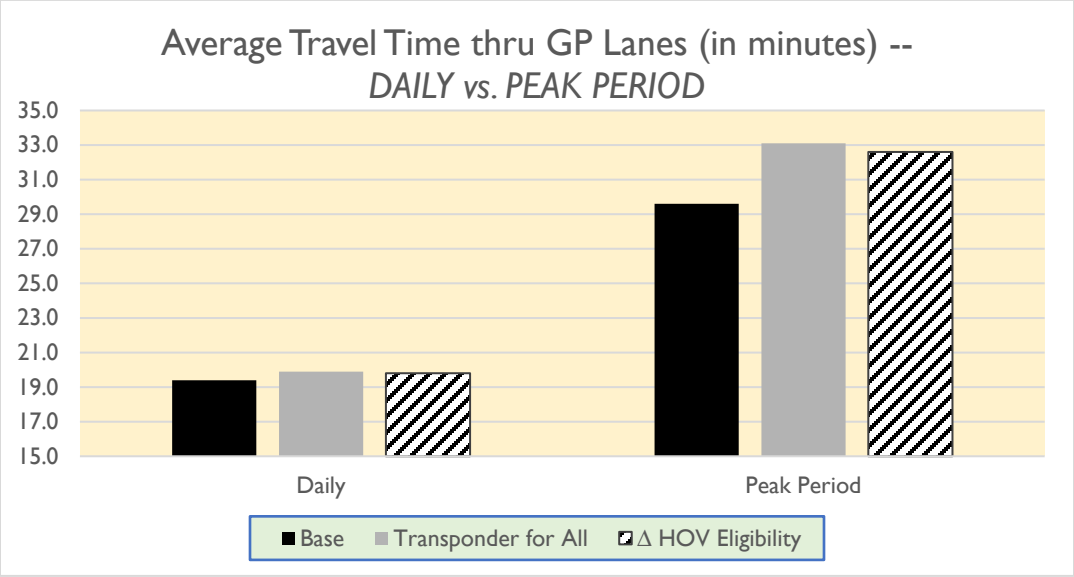
- The reduction in travel times through the Express Lanes is a reflection of the increased EL speeds documented in Performance Measure #5.
- The "Transponder for All" strategy is slightly more effective at improving speeds and reducing travel times, as compared to the "Δ HOV Eligibility" strategy.
- The proposed strategies have a stronger impact during peak periods (as compared to conditions on an "average daily" basis), reducing full-length travel times by one to one-and-a-half minutes.

Performance Measure #7 – GP Lanes Speeds (peak period)



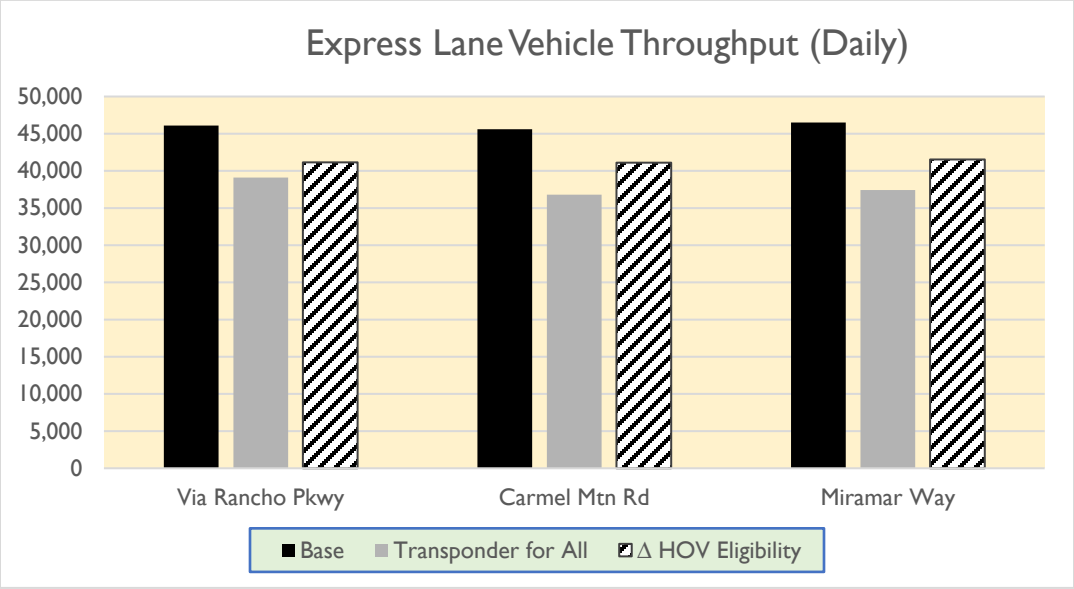
- The proposed strategies reduce peak-period speeds in the GP lanes by up to 10%. At Via Rancho, peak-period speeds in the GP lanes fall by 3-4 miles per hour. At Carmel Mountain Rd., the impact is slightly less (2-3 mph). At Miramar Way, the difference is negligible.
- The decline in speeds is caused by some vehicles shifting from the Express Lanes to the GP lanes. Because the proposed strategies add new requirements for toll-free use of the Express Lanes, some vehicles will choose to use the GP lanes instead. This additional traffic during peak periods slightly elevates the level of congestion, causing speeds to decline.

Performance Measure #8 – Average Travel Time thru GP Lanes (daily & peak period)



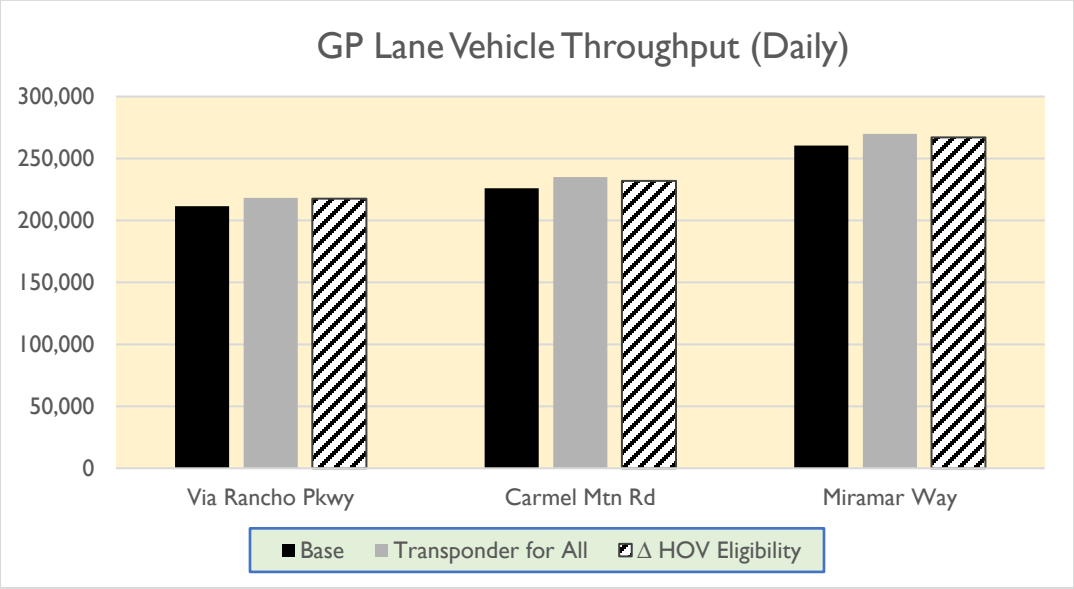
- The proposed strategies have very little effect on travel times through the GP lanes on an "average daily" basis.
- However, during peak periods, the proposed strategies are expected to increase travel times by 3-4 minutes. This reflects the decreased peak-period travel speeds identified in Performance Measure #7.

Performance Measure #9 – Express Lanes Vehicle Throughput



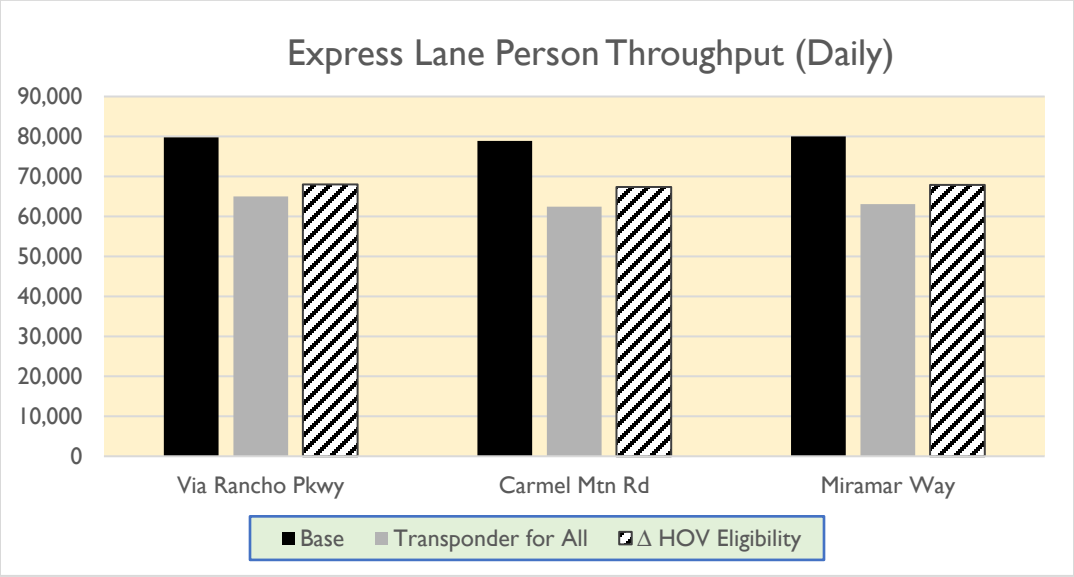
- Both measures tend to decrease the number of vehicles using the Express Lanes on a daily basis.
- As mentioned before, usage decreases because each strategy adds a new eligibility requirement for using the Express Lanes for toll-free travel. In other words, by making it more difficult to use the Express Lanes for free, the strategy decreases the number of users.
- The requirement of transponder usage for HOVs is expected to reduce usage by 15-20%, while simply increasing the HOV requirement is expected to reduce usage by about 10%.

Performance Measure #10 – GP Lanes Vehicle Throughput



- Both strategies tend to increase vehicle throughput in the GP lanes.
- The impact is modest, ranging from 2.5% to 4.0%, depending on the location and the strategy chosen.
- The increase results from vehicles shifting out of the Express Lanes as a result of the increased requirements for toll-free usage of the facility.

Performance Measure #11 – Express Lanes Person Throughput



- By reducing the number of vehicles using the Express Lanes (see Performance Measure #9), the proposed strategies also reduce the person throughput of the Express Lanes.
- The "Transponder for All" strategy tends to reduce person throughput by approximately 18-20%, while the "Δ HOV Eligibility" strategy is projected to yield a reduction of about 15%.

APPENDIX G: OPERATIONAL STRATEGY PERFORMANCE FINDINGS TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, Todd Pendleton, HNTB

Date: February 28, 2020

Subject: Operational Strategy Performance Findings Technical Memorandum

Purpose

The purpose of this memorandum is to describe the operational strategies evaluated under Task 3 of this study, the associated operational and performance assessment findings, and the related impacts and benefits of each strategy. The memo documents the performance impacts associated with three key operational strategies believed to have potential to improve existing operational deficiencies documented during Task 2.

Performance Measure Summary

The "existing conditions" analysis completed under Task 2 defined a series of performance measures used to evaluate the operation of the I-15 Express Lanes (EL). Task 3 evaluated the likely impact of two key operational strategies on these performance measures. These two strategies include:

- **Strategy #1 – Transponder for All**. This strategy requires all users of the EL to have a transponder, regardless of the number of occupants.
- **Strategy #2 – Change HOV Eligibility**. This strategy increases the required number of occupants (for toll-free travel) from HOV2+ to HOV3+.

In addition, HNTB evaluated the operational implications of increasing the maximum toll rate above the current $8 maximum toll. The **Strategy #3 – Increase Maximum Toll** review includes a high-level analysis of the expected operational impacts; however, data is not currently available to detail the likely impacts to the performance measures defined for this study.

The three operational strategies cited above were selected for two key reasons:

- First, these operational strategies align with business rules currently in effect in Los Angeles County, Orange County, Riverside County, and other facilities (both planned and operational) throughout California. Thus, any implementation of these strategies would enhance regional consistency of Express Lanes operations.
- Second, these operational strategies provide the tools necessary to address the deficiencies identified during the existing conditions analysis (Task 2) and achieve the CMT's goals and objectives documented in Task 2, such as providing and maintaining reliable and predicable travel times in the I-15 Express Lanes. The region is growing, and the I-15 corridor will inevitably become more heavily traveled. These strategies have been implemented in other locations to maintain a reliable travel alternative in the midst of increasing congestion.

Please note that these three strategies were evaluated independently of each other in order to understand the potential of each strategy to independently impact operations. Should SANDAG determine that two or

more strategies should be employed to help achieve the regional plan and CMT's goals and objectives for the corridor, analysis could be conducted to forecast the impact of a combining them.

Denver Case Study

Background

HNTB based portions of its analysis on a detailed review of operation on two managed lane facilities in greater Denver—namely, the I-25 Central Express Lanes and the US-36 Express Lanes. These facilities are operated by Plenary Roads Denver, a private consortium with a 50-year contract to operate and maintain the I-25 Central Express Lanes, the US-36 Express Lanes, and the US-36 General Purpose lanes. HNTB chose to perform a case study of these facilities for two primary reasons:

- First, the orientation of these facilities in metropolitan Denver—connecting residential and commercial areas in highly-developed suburban to an urban core—is very similar to the I-15 Express Lanes.
- Second, the I-25 Express Lanes is the only known example of a facility in the United States that has experienced two of the operational strategies considered in this study - namely, the addition of a requirement to have a transponder as well as the increase in occupancy requirement from HOV2+ to HOV3+.

The facilities reviewed by HNTB are both two-lane roadways on the north side of Denver. They are described as follows:

- The I-25 Central Express Lanes is a 2-lane reversible facility running between 20th Street in Downtown Denver and the US-36 interchange located 5 miles to the north. The facility operates with both lanes oriented southbound (toward downtown) from 5am to 11am, and with both lanes oriented northbound from noon to 3am. The lanes are barrier-separated from the general purpose lanes. One toll point, located in the middle of the corridor, captures all users of the Express Lanes, since there are no intermediate access points.
- The US-36 Express Lanes is a 2-lane facility extending for 16 miles from I-25 in the southeast to the outskirts of Boulder in the northwest. Unlike the I-25 Central Express Lanes, it is not reversible; rather, it provides 1 lane in each direction for 24/7 tolling.

Both facilities currently operate with time-of-day pricing. Tolls follow a published pricing schedule, with higher prices being charged during peak travel times. The toll schedule may be adjusted periodically (typically on an annual basis) in order to enable the operator (Plenary Roads Denver) to manage demand and maintain free-flow conditions in the Express Lanes.[1]

The I-25 Central Express Lanes originally opened in June 2006 as an HOV2+ facility. For the first 9 years, HOV2+ vehicles could use the Express Lanes without a transponder, provided that the vehicle's license plate was registered to an account. Drivers "declared" their occupancy, via lane selection, as they passed through the toll point.

[1] Both the I-25 Central Express lanes and the US-36 Express Lanes are in the process of converting to dynamic pricing, whereby prices change in real time in response to prevailing traffic conditions. But as of December 2019, dynamic pricing had not been implemented.

- Drivers declaring as high-occupancy could use the designated "HOV" lane with no toll being assessed, provided that the vehicle had a transponder *or* was registered on a valid license plate account.
- Single-occupant drivers were required to use the designated "SOV" lane, in which tolls were assessed for vehicles with a valid transponder or that were registered on a valid license plate account. For vehicles with neither a transponder nor having set up a license plate account, a violation notice was sent to the corresponding address provided by the Colorado Department of Motor Vehicles.

Beginning in 2009 the concept of a "License Plate Toll" customer was introduced. For all vehicles without a transponder passing through the toll point, an image was taken. If the plate was not registered on a valid license plate account, then a toll bill was sent to the corresponding address provided by the Colorado Department of Motor Vehicles. If not paid, the toll bill was escalated to a violation notice.

Beginning in July 2015 and corresponding with the opening of the I-36 Express Lanes, which directly connected with and extended the I-25 Central Express Lanes, the occupancy declaration via lane selection was discontinued. All drivers of high-occupancy vehicles were now required to declare their occupancy via a switchable transponder. Registered vehicles without a switchable transponder set to "HOV" were assessed a toll; unregistered vehicles receive a toll bill.

Prior to this change, vehicles could register their license plate with the facility in lieu of acquiring a transponder. Then they could self-declare as an HOV by driving through the designated "HOV" lane at the toll point. This provided a way for HOVs to travel for free without a transponder. This option was eliminated in July 2015. Therefore, the I-25 Central Express Lanes serve as a helpful case study of the impacts of incorporating a transponder requirement for all HOV users.

In January 2017, both the I-25 Central Express Lanes and the US-36 Express Lanes converted to HOV3+ facilities. Vehicles with switchable transponders would now be required to have 3 or more occupants in order to self-declare as an HOV. All SOV and HOV2 vehicles would be required to pay the posted rate; no discount was provided to HOV2 vehicles. The experiences recorded from this transition can shed some light on the likely impacts if a similar conversion were to be effected on the I-15 Express Lanes.

Limitations of Analysis

The Denver facilities cited above were selected as a case study because (a) their conversions were comparable to the operational strategies being evaluated as part of the Task 3 analysis for I-15, and (b) data was publicly available for review and analysis. However, care must be taken when drawing conclusions from the analysis.

- First, the data available for the Denver facilities did *not* include information regarding violations. Prior to the implementation of a transponder requirement for HOVs, vehicles that "declared" as HOVs were classified as HOVs, regardless of the actual number of occupants. The publicly-available data did not have any estimate of the percentage of drivers that were violating (i.e. declaring as HOVs despite being SOVs).
- Second, the Denver facilities did require HOVs without a transponder to register their license plates in order to travel for free. This differs from the I-15 EL, in which the only condition for toll-free travel without a transponder is to have 2 or more occupants.
- Third, the conversion from HOV2+ to HOV3+ in Denver was made after imposing a transponder requirement. However, the analysis in this document estimates the impact of converting from HOV2+

to HOV3+ *without* a transponder requirement (consistent with current policy). Therefore, the Denver experience is informative but must be understood in its context.

Of course, the manner in which drivers choose to use Express Lanes is a function not only of policy, but also of the degree to which a comprehensive marketing and outreach program is employed to support these policies. In some cases, there may be a lengthy delay between a policy change and a behavioral response, as drivers take time to process new information and decide whether and how to change their travel patterns. Therefore, while the Denver I-25 Case Study is a helpful reference point, its context is certainly not identical to the I-15 Express Lanes. Thus, the observed impacts of the policy changes (to be discussed in the next section) are *informative* but certainly not *prescriptive* of what would happen on the I-15 Express Lanes under similar changes.

Impacts of Policy Changes

Over the course of 12 months following the imposition of a transponder requirement for HOVs, the I-25 Central Express Lanes experienced the following changes:

- The total volume of Express Lane usage fell by 18%;
- The market share of single-occupant vehicles grew by about 16%; and,
- Revenue increased by roughly 45%.

The subsequent conversion from HOV2+ to HOV3+, implemented in January 2017, had the following impacts on the Express Lanes:

- The market share of toll-paying traffic grew by 9% on I-25 and by 12% on US-36.
- The market share of high-occupancy vehicles fell by 8% on I-25 and by 11% on US-36.
- The market share of vehicles carrying 3 or more occupants appeared to increase slightly, although the baseline data in this regard is not very detailed.
- In the 12 months following the conversion to HOV3+, revenue on I-25 grew by over 30% while revenue on US-36 grew by over 60%.

Methods and Assumptions

The following bullets summarize the key elements of HNTB's methodology as well as the critical assumptions underlying our I-15 EL analysis.

- HNTB assumed that today's I-15 EL violators—which currently comprise 15% to 27% of the users of the Express Lanes—can be divided into "Group 1" and "Group 2" violators. We assumed that Group 1 (the "Hard Violators") make up 5% of the EL users; they will continue to violate regardless of any policy changes.[2] The remainder are assumed to belong to Group 2, whose behavior is subject to change based on the details of the policy being implemented.
- Under current policy, HOVs are not required to have a transponder. However, for analysis purposes, HNTB assumed that 20% of true HOVs using the Express Lanes have a switchable transponder

[2] This estimate is based on HNTB's experience with observing Express Lanes throughout the country. This experience reveals that a small number of users will attempt to bypass the fare collection system and travel for free, regardless of the enforcement policy.

(acquired from other agencies) that is toggled to HOV mode. All other true HOVs are vehicles with the required number of occupants but with no transponder.

- The following assumptions governed the impact of the "Transponder for All" policy:
  - Of the Group 2 violators, 50% acquire a transponder and convert to paying SOV customers. The other 50% shift to the GP lanes.
  - Of the current HOV travelers that do not have a transponder:
    - 65% acquire a transponder and continue to use the EL
    - 30% do not acquire a transponder and shift to the GP lanes instead
    - 5% do not acquire a transponder, but continue to use the EL as violators
- The following assumptions governed the impact of the "Change HOV Eligibility" policy:
  - This policy has no impact on current HOV3+ users
  - Of the current HOV2 users of the Express Lanes that already have a transponder:
    - 55% continue to use the EL as paying customers
    - 25% shift to the GP lanes to avoid the new toll
    - 15% add a passenger and become HOV3+ vehicles
    - 5% become violators
  - Of the current HOV2 users of the Express Lanes that do not have a transponder:
    - 55% acquire a transponder and continue to use the EL as paying customers
    - 25% shift to the GP lanes to avoid the new toll
    - 10% add a passenger and become HOV3+ vehicles
    - 10% become violators
- The high-level revenue estimates contained in this report assume that revenue is directly related to the number of paying vehicles. So, if a policy is projected to increase the number of paying vehicles by 10%, then the revenue will also be projected to increase by 10%.
- For "person throughput" calculations, it is assumed that HOV3+ vehicles carry an average of 3.1 occupants per vehicle.
- HNTB translated volume changes into speed changes via the use of speed-flow curves developed for both the general purpose (GP) lanes as well as the Express Lanes (EL). The speed-flow curves were developed by HNTB through a detailed examination of speeds and volumes captured during peak periods. The GP lane data was gathered via Caltrans' Performance Monitoring System (PeMS), while the EL data was gathered from the toll system.
- HNTB's evaluation focused on the changes that would occur in the immediate aftermath of implementing the proposed policy changes. The evaluation did *not* project the impact of the proposed changes over an extended period of years. However, the Denver case study demonstrated that these tools provide the ability to extend the number of years for which an Express Lanes facility can provide a reliable alternative route bypassing congestion in the GP lanes.

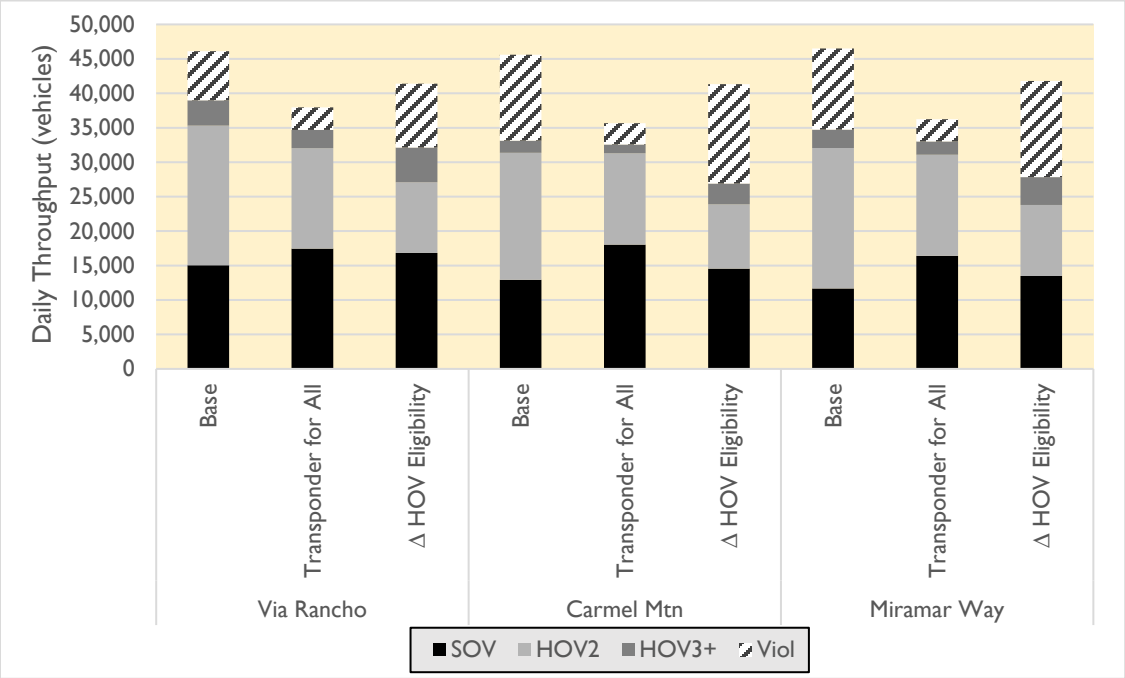
The remainder of the report will review the impact of the two aforementioned operational strategies on 11 different performance measures identified during Task 2.

Analysis Results – Strategy #1 (Transponder for All) and Strategy #2 (Change HOV Eligibility)

For each of the performance measures, a graphic summarizing the results of HNTB's analysis is provided. In reviewing these graphics, please note the following:

- In most cases, the graphics are divided into three groups, with each group representing a geographic cross-section of the existing I-15 Express Lanes. For example, the graphic for Performance Measure #1 illustrates the projected market share of I-15 EL throughput at three locations—Via Rancho Parkway (northern portion of the EL), Carmel Mountain Rd. (central portion), and Miramar Way (southern portion).
- In most cases, the graphic is followed by a discussion of key points highlighted by the graphic's underlying data. The supporting calculations are generally not provided in the discussion in order to support readability.
- When a "range" of results is provided, it is designed to acknowledge that the impact of a given strategy may vary by location throughout the corridor.
- As noted earlier, these two strategies are assessed independently. The assessment of the impact of requiring transponder usage was performed on the assumption that the current HOV requirement (HOV2+) is unchanged. Similarly, the assessment of the impact of increasing the HOV requirement was performed on the assumption that transponder usage will NOT be required of HOV users.

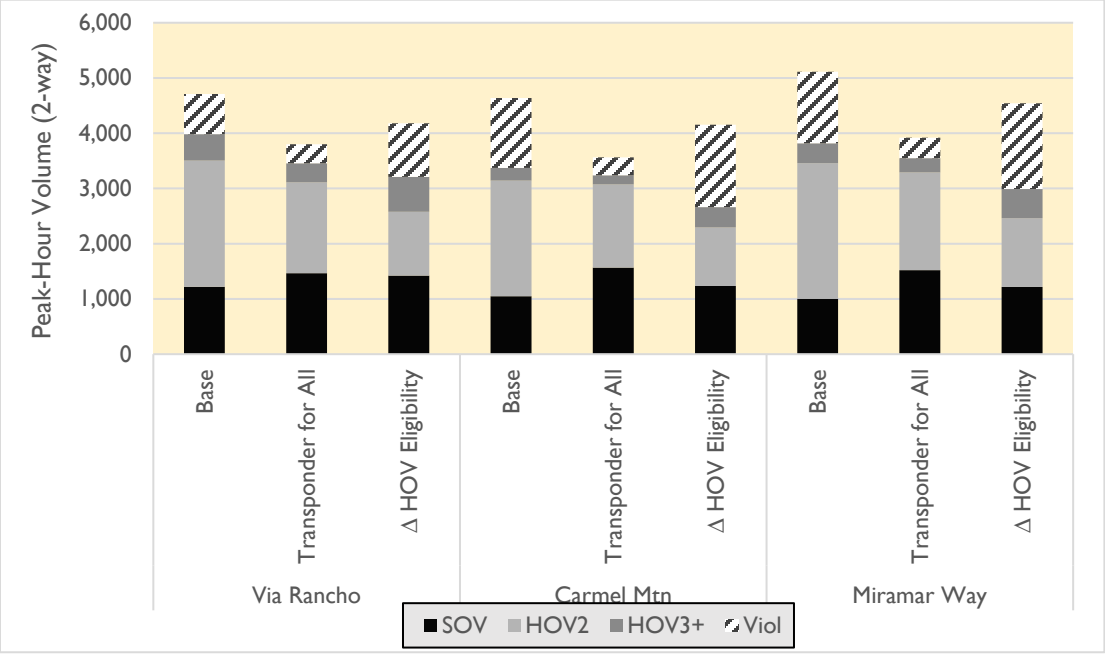
Performance Measure #1 – Express Lanes Vehicle Throughput (Daily)



- Both measures tend to decrease the number of vehicles using the Express Lanes daily. However, the "Transponder for All" strategy tends to maintain the number of *valid* transactions constant; it just reduces the number of violations transactions.

- The "Transponder for All" strategy is expected to significantly reduce the number of violations. This is because the strategy will be accompanied by video enforcement. All drivers who use the facility without a transponder in the future will have an image taken of their license plate and will be sent a violations notice in the mail. Experience has shown this is far more effective at reducing violations than the current approach, which is solely based on visual observation by law enforcement.
- As mentioned before, usage decreases because each strategy adds a new eligibility requirement for using the Express Lanes for toll-free travel. In other words, by making it more difficult to use the Express Lanes for free, the strategy decreases the number of users.
- However, although both strategies decrease the total number of vehicles using the Express Lanes, they *increase* the number of single-occupant vehicles (SOVs). As Performance Measure #14 will illustrate, this could result in increased revenue since it is expected that there will be an increase in toll-paying vehicles.
- The requirement of transponder usage for HOVs is expected to reduce usage by 17-22% compared to existing conditions, while simply increasing the HOV requirement is expected to reduce usage by about 10-11%.
- If the HOV requirement is increased <u>without</u> imposing a transponder requirement, then it is likely that many HOV2 vehicles will continue to behave as they do today—using the HOV lanes without a transponder. This group of users will now be considered as violators. Therefore, in the "Change HOV Eligibility" strategy, both the **number** and the **percentage** of violators is likely to increase.

Performance Measure #2 – Express Lanes Vehicle Throughput (Peak Hour)

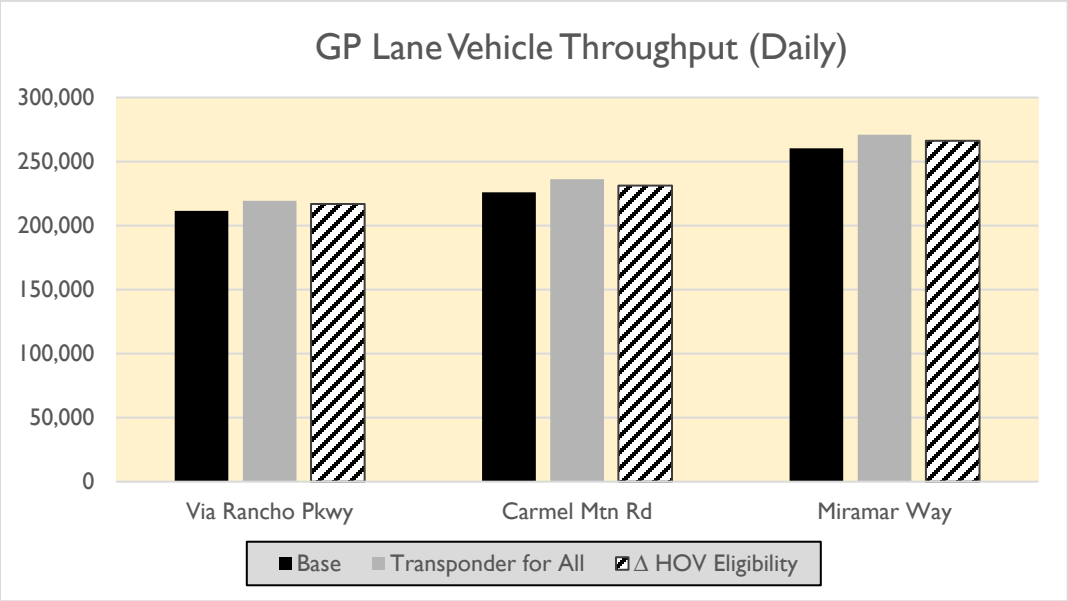


- The Express Lanes throughput trends observed in the "daily" analysis carry over to the "peak hour" analysis. Both strategies tend to decrease Express Lanes throughput, with the reduction in the

"Transponder for All" strategy being more significant than the reduction in the "Change HOV Eligibility" strategy. The "Transponder for All" strategy tends to yield only a very minor reduction in the number of valid vehicle transactions; its primary impact is to reduce the number of violations transactions. As noted above, the effectiveness of the "Transponder for All" strategy with respect to reducing violations is largely connected to the video enforcement capability that will accompany the strategy.

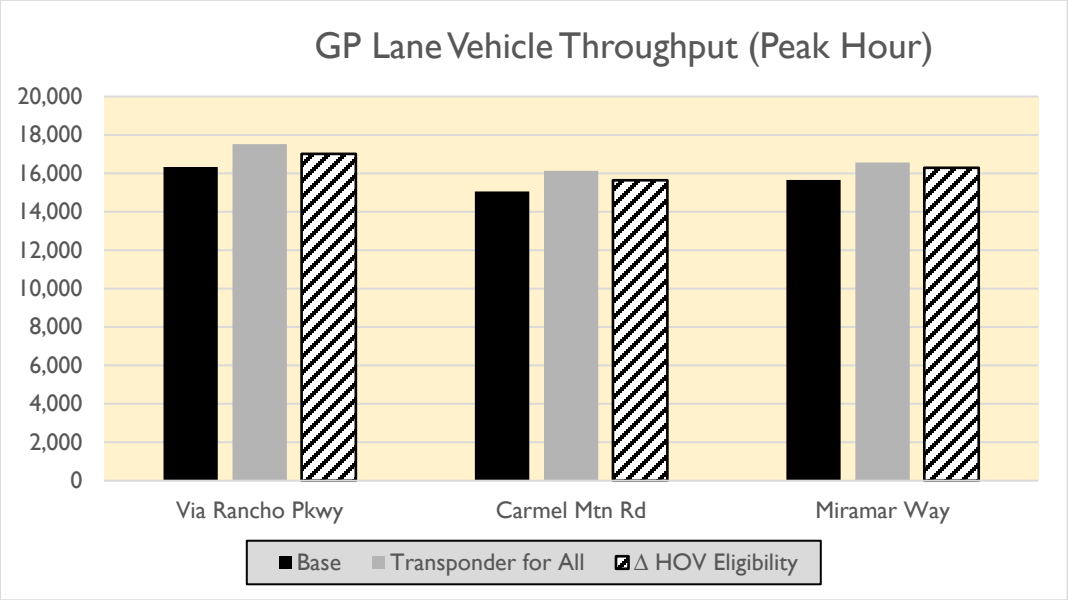
- The relative impact in the peak hour is very similar to the impact on a daily basis (Performance Measure #1). The requirement of transponder usage for HOVs is expected to reduce peak-hour usage by 19-23%, while simply increasing the HOV requirement is expected to reduce usage by about 11-12%.

Performance Measure #3 – GP Lanes Vehicle Throughput (Daily)



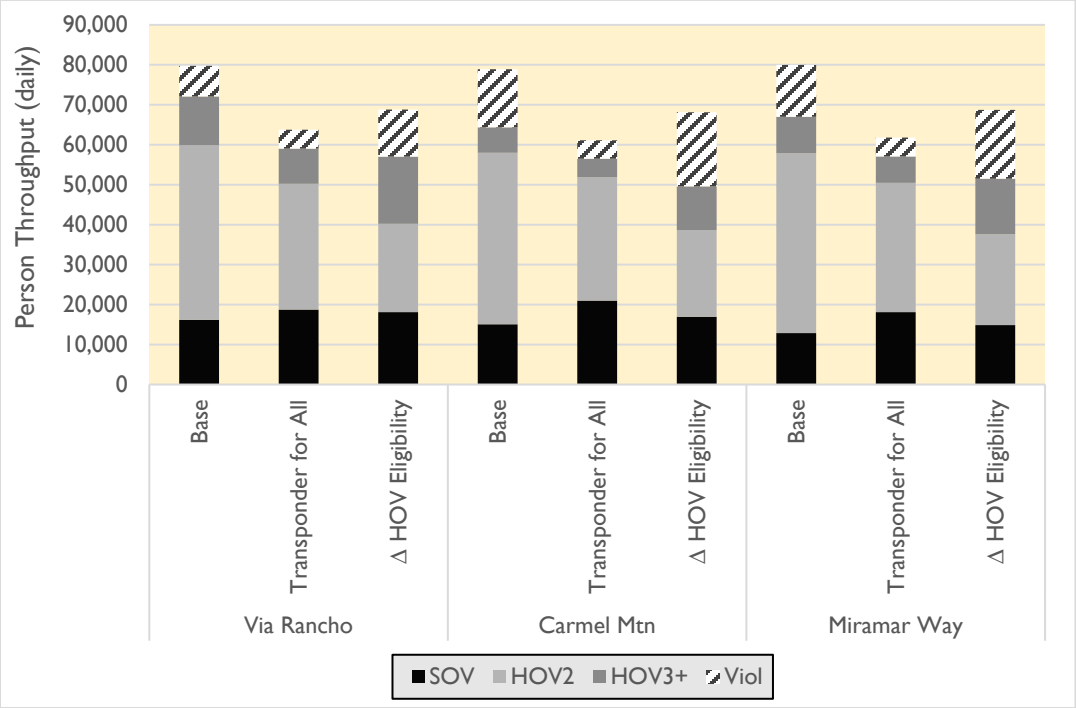
- Both strategies tend to increase vehicle throughput in the GP lanes, ranging from 2.3% to 4.5%, depending on the location and the strategy chosen.
- The increase in GP traffic volume is the result of vehicles shifting out of the Express Lanes as a result of the enhanced requirements for toll-free usage of the facility.

Performance Measure #4 – GP Lanes Vehicle Throughput (Peak Period)



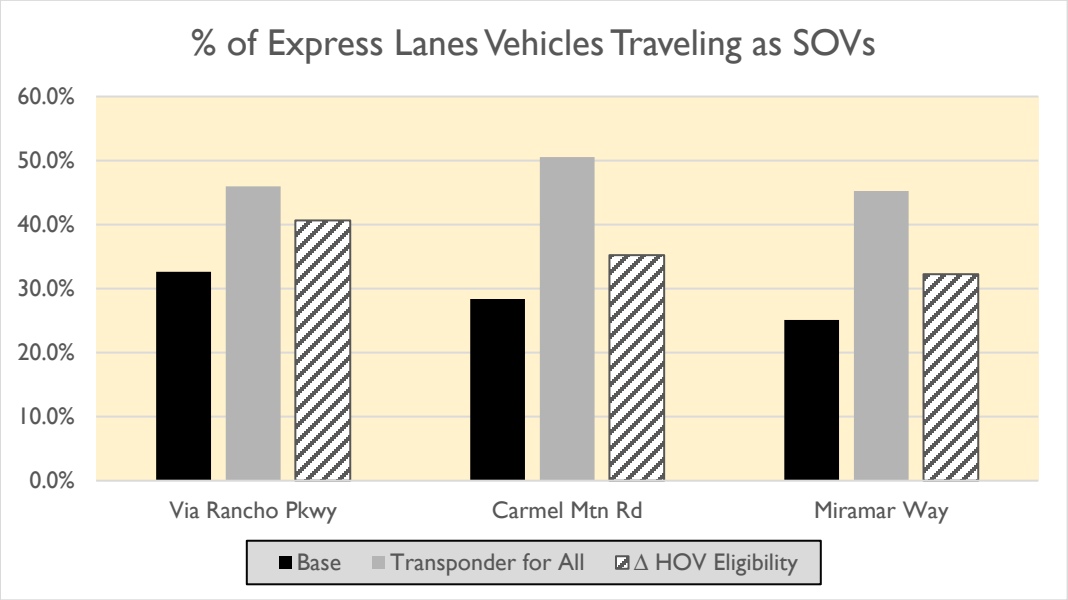
- During the peak hour, both strategies tend to increase vehicle throughput in the GP lanes. This is consistent with the assessment made on daily traffic (Performance Measure #3).
- The impact results in a 4-7% increase in throughput during the peak hour. However, during peak travel periods, small increases in traffic can yield significant reductions in travel speeds. This will be evaluated as part of Performance Measure #12.

Performance Measure #5 – Express Lanes Person Throughput



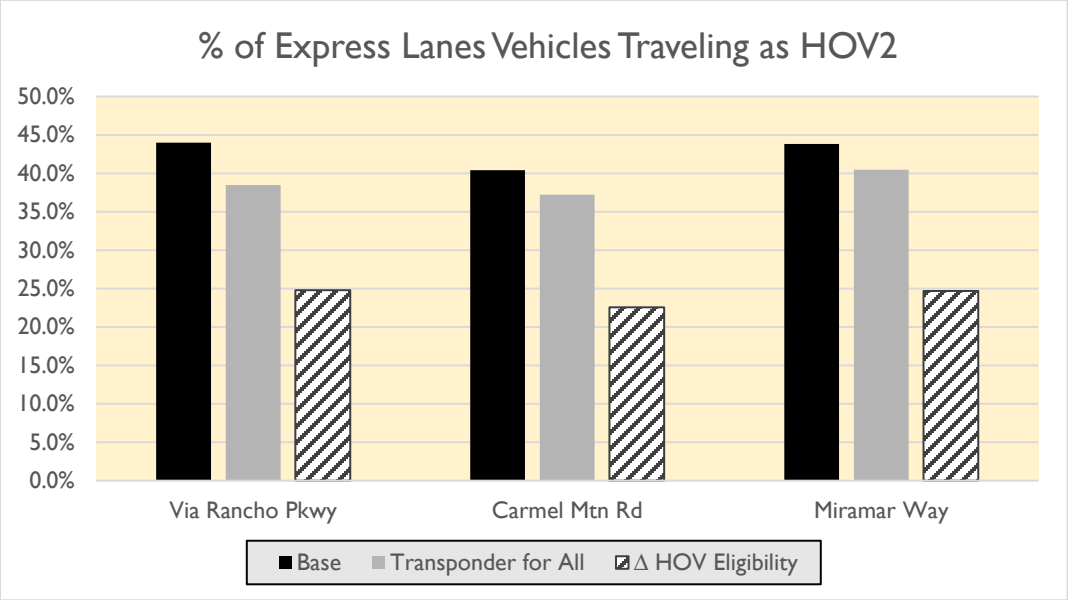
- By reducing the number of vehicles using the Express Lanes on a daily basis (see Performance Measure #1), the proposed strategies also reduce the person throughput of the Express Lanes.
- The "Transponder for All" strategy tends to reduce person throughput by approximately 20-23%, while the "Change HOV Eligibility" strategy is projected to yield a reduction of about 16%.
- As noted in the evaluation of Performance Measures #1 and #2, the "Transponder for All" strategy is expected to reduce the number of violations by 50-75%. Experience has shown that the combined impacts of requiring transponders and implementing video enforcement greatly reduces the incentive to violate.

Performance Measure #6 – Percentage of Express Lane Vehicles Traveling as SOVs



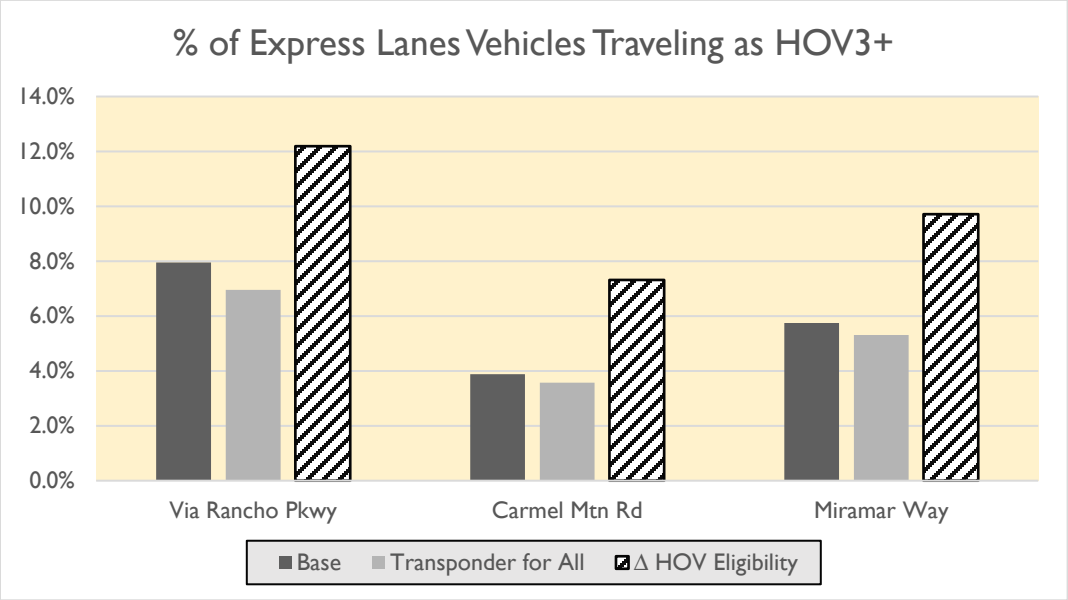
- Both strategies are expected to increase the percentage of vehicles that travel as SOVs.
- The reason is that both strategies add requirements for free usage of the Express Lanes. The "Transponder for All" strategy adds requirements by mandating that all high-occupancy vehicles to acquire a transponder. The "Change HOV Eligibility" strategy adds requirements by mandating that all high-occupancy vehicles have 3 or more occupants to qualify for free travel.
- In short, these strategies make it slightly harder for drivers that currently use the lanes for free to continue doing so. As a result, it is expected that some existing HOV vehicles will divert to the GP lanes, resulting in a greater proportion of the vehicles are expected to be SOVs.

Performance Measure #7 – Percentage of Express Lane Vehicles Carrying 2 People



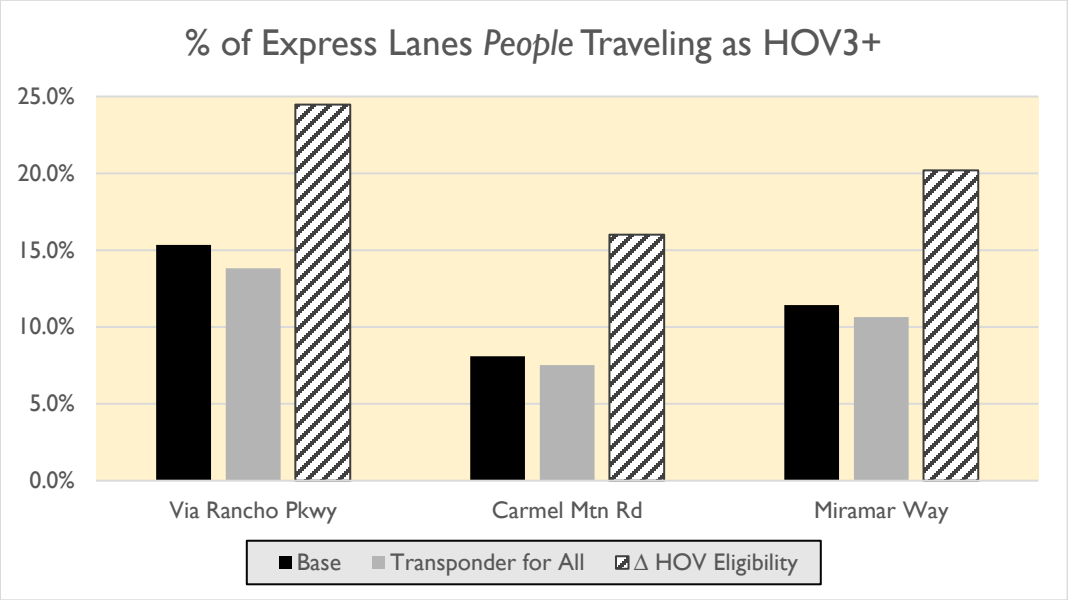
- This is a mirror image of Performance Measure #6. In other words, the *increase* in the percentage of SOVs is reflected by a *decrease* in the percentage of HOV2 vehicles.
- In existing conditions, HOV2 vehicles may travel for free with no transponder. Both above-listed strategies change this. The "Transponder for All" strategy adds a requirement to acquire a transponder to travel for free; the "Change HOV Eligibility" strategy adds a requirement to add a passenger to travel for free.
- Since it is generally more difficult to add a passenger than to acquire a transponder, the "Change HOV Eligibility" strategy has a greater impact on reducing the share of HOV2 vehicles.
- NOTE: This graphic summarizes actual declared HOV2 vehicles. This graphic will slightly overstate the reduction in HOV2 vehicles, since—in either strategy—some existing HOV2 vehicles will become violators (and are thus not accounted for in the graphic above).

Performance Measure #8 –Percentage of Express Lane Vehicles Carrying 3+ People



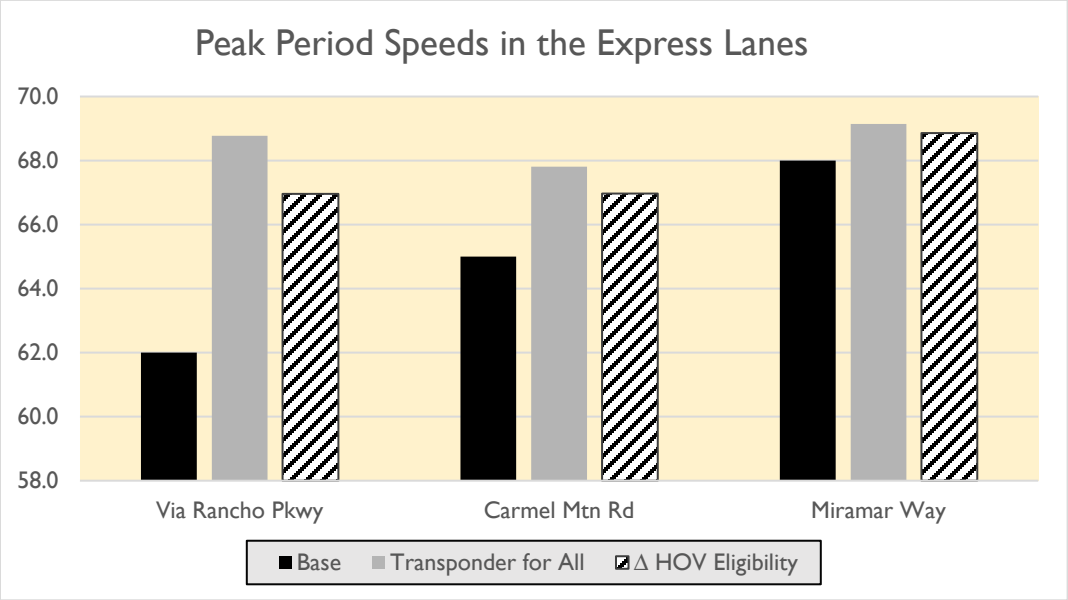
- The "Transponder for All" strategy results in a decline in the share of vehicles traveling as HOV3+ vehicles, since—as noted earlier—the addition of a new requirement for Express Lane usage yields a slight decline in the number of HOV3+ vehicles. However, the decline is fairly small—typically less than a percentage point.
- The "Change HOV Eligibility" strategy results in an *increase* in the share of vehicles traveling as HOV3+ vehicles. This strategy does not impact existing HOV3+ users, but it provides a significant cost-saving incentive for other users (both SOVs and HOV2) to add passengers and become HOV3+ vehicles. As a result, the number (and market share) of HOV3+ vehicles grows.

Performance Measure #9 – Percentage of *People* in Express Lanes Traveling as HOV3+



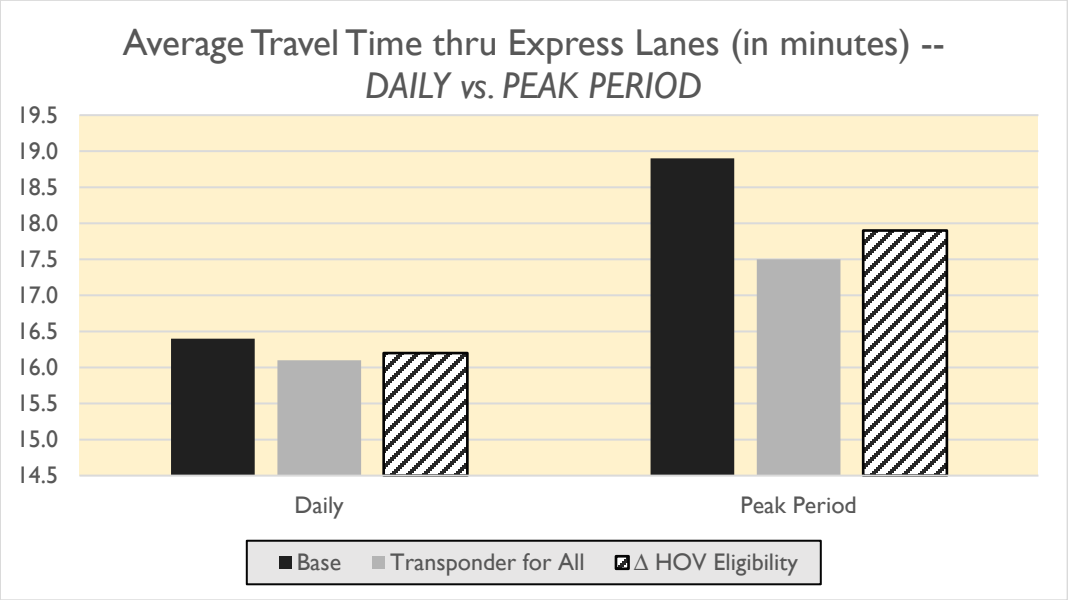
- The trends in this performance measure mirror the trends in Performance Measure 8, since the number of *people* served by the Express Lanes is a function of the number of *vehicles*.
- The "Change HOV Eligibility" strategy yields an increase of approximately 8% in the share of people conveyed by HOV3+. This strategy yields a condition in which 15-25% of people are carried via HOV3+ vehicle, even though these vehicles comprise less than 10% of the Express Lanes traffic stream.

Performance Measure #10 – Express Lanes Speeds (peak period)



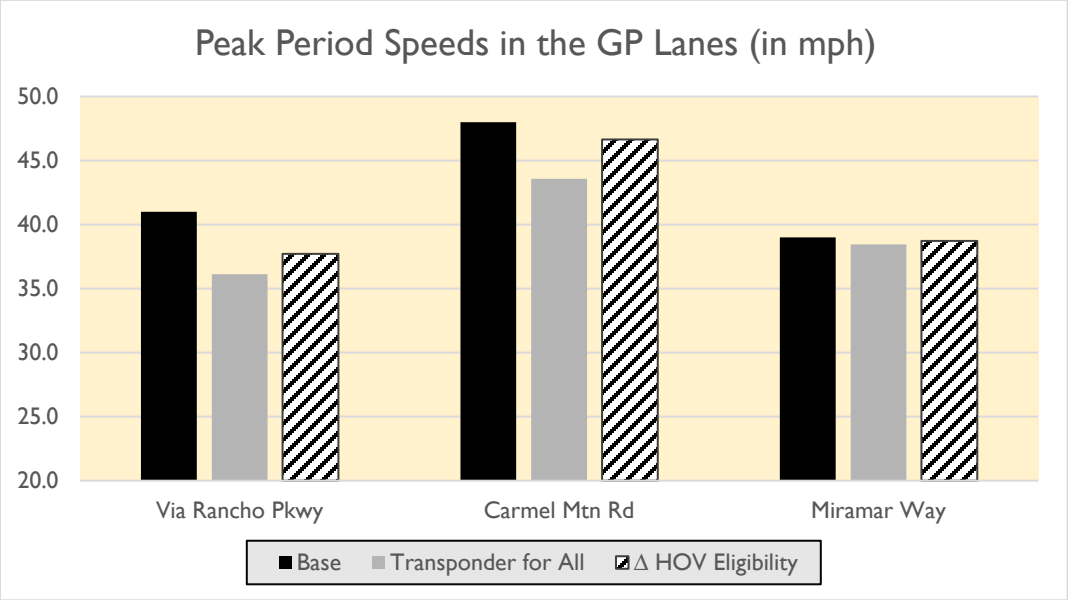
- Both strategies have a positive impact on the Express Lanes by improving peak-period speeds.
- Although these strategies increase the number of *paying* users in the Express Lanes, they reduce the number of *total* users. This reduction takes place as a result of adding requirements for toll-free use of the Express Lanes.
- This reduction in overall volume helps reduce peak-period congestion and therefore increases the average peak-period speed. The "Transponder for All" strategy essentially restores congestion-free conditions by providing average speeds that consistently are in the vicinity of 68 mph (or better).

Performance Measure #11 – Average Travel Time thru Express Lanes (daily & peak period)



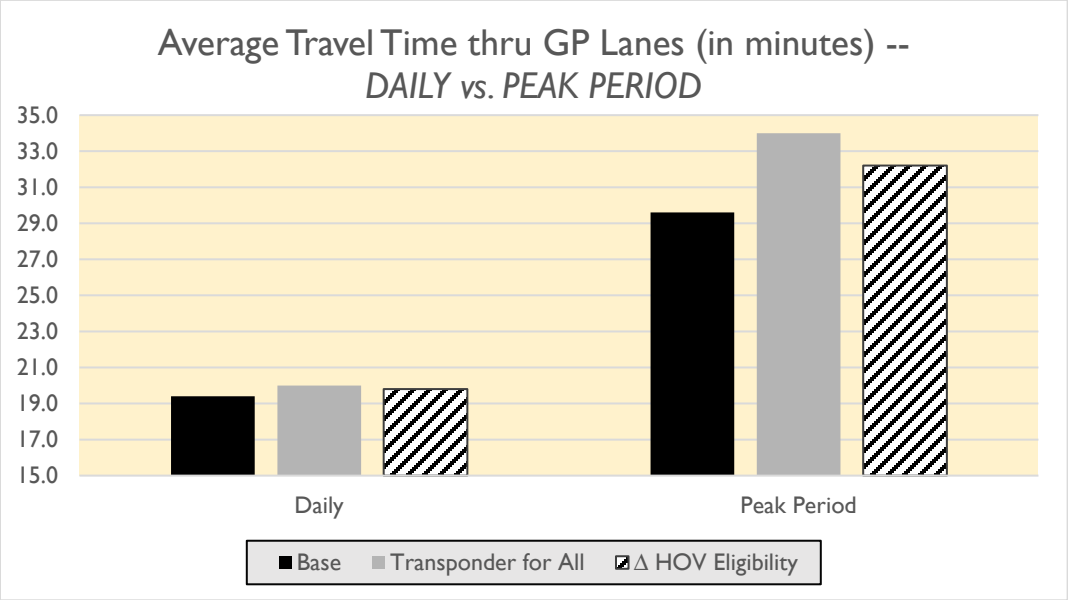
- The reduction in travel times through the Express Lanes reflects the increased EL speeds documented in Performance Measure #10.
- The "Transponder for All" strategy is slightly more effective at improving speeds and therefore reducing travel times, as compared to the "Change HOV Eligibility" strategy.
- The proposed strategies have a stronger impact during peak periods (as compared to conditions on an "average daily" basis), reducing full-length travel times by one to one-and-a-half minutes.

Performance Measure #12 – GP Lanes Speeds (peak period)



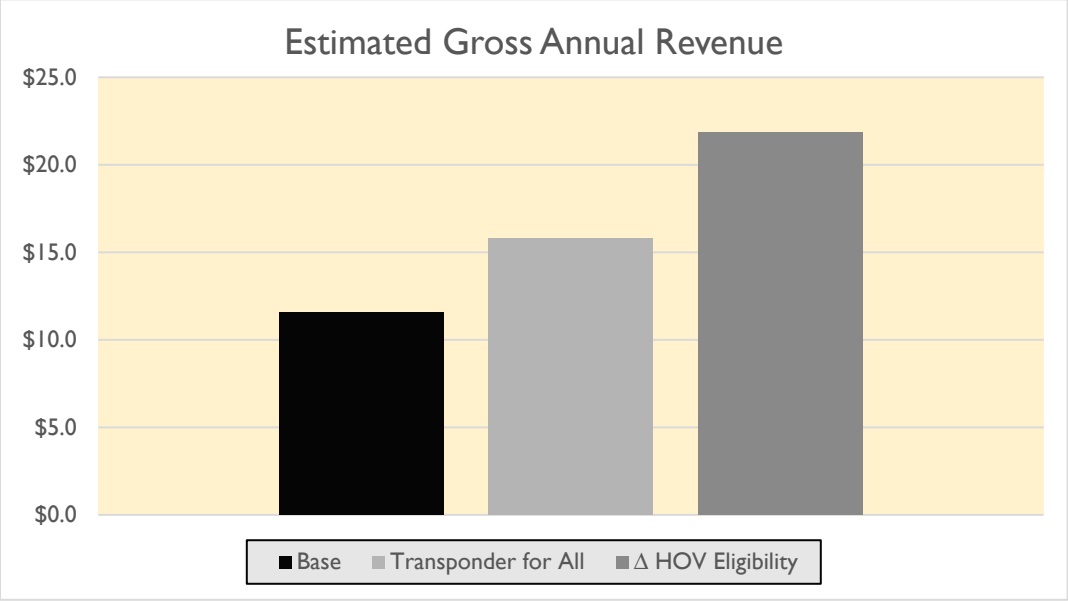
- The proposed strategies reduce peak-period speeds in the GP lanes by up to 10%. At Via Rancho and Carmel Mountain Rd., peak-period speeds in the GP lanes fall by about 2-5 miles per hour. At Miramar Way, the difference is negligible for both strategies.
- The decline in speeds is caused by some vehicles shifting from the Express Lanes to the GP lanes. Because the proposed strategies add new requirements for toll-free use of the Express Lanes, some vehicles will choose to use the GP lanes instead. This additional traffic during peak periods slightly elevates the level of congestion, causing speeds to decline.

Performance Measure #13 – Average Travel Time thru GP Lanes (daily & peak period)



- The proposed strategies have very little effect on travel times through the GP lanes on an "average daily" basis.
- However, during peak periods, the proposed strategies are expected to increase travel times by 3-4 minutes. This reflects the decreased peak-period travel speeds identified in Performance Measure #12.

Performance Measure #14 – Express Lanes Annual Revenue



- HNTB's revenue analysis made a high-level assumption that revenue is directly related to the number of toll-paying vehicles.
- Experience has shown that introducing a transponder requirement will tend to encourage some existing violators to acquire transponders and become paying customers. For this reason, the number of paying users of the Express Lanes tends to increase, resulting in more revenue.
- Increasing the HOV requirement (from HOV2+ to HOV3+) also tends to increase the number of paying customers, since the HOV2s who choose to continue to use the Express Lanes are required to pay a toll.
- The data suggests that changing the HOV requirements has a larger impact on gross revenue than simply incorporating a transponder requirement, since it greatly increases the number of users from whom a toll is required.

Analysis Results – Strategy #3 (Increase Maximum Toll)

HNTB was also asked to evaluate the operational implications of increasing the maximum toll. At present, the maximum toll for any trip on the I-15 Express Lanes is $8.00. This maximum toll has been in effect since the first eight-mile (reversible) segment opened in 1998. The maximum toll did not increase even as the facility progressively expanded to its current length of 20 miles.

HNTB considered the implications of establishing a maximum toll rate of *$1.00 per mile*, consistent with the per-mile maximum toll rate that was in effect when the facility first opened. This policy would yield a de facto maximum toll of $20 for a 20-mile thru trip. Shorter trips would have a lower resulting toll.

Limitations on the availability of data has constrained HNTB's ability to precisely forecast the impact of increasing the maximum toll in this manner. The data provided to HNTB is not sufficiently detailed to identify the percentage of trips (on a peak-period basis) that are impacted by the capped $8.00 toll. Data regarding origin-destination trips was compiled on a daily basis, but the same data could not be compiled on an hourly or sub-hourly basis. For this reason, it is difficult to project, during peak periods (when travel conditions are most critical), the number of trips whose behavior could be modified through the imposition of a higher toll.

However, the daily data did provide some information that provides insight regarding the potential impact of raising the maximum toll. **Error! Reference source not found.** summarizes some key outputs of the analysis of daily origin-destination data extracted for Tuesday, September 10, 2019; and for Thursday, September 12, 2019. The data is presented by day and by direction (NB vs. SB). In reviewing the data contained in **Error! Reference source not found.**, please note the following:

- All data relates to toll-paying SOV trips. The totals relating to VMT and trips do *not* incorporate data from non-tolled traffic (e.g. HOVs and violators).
- All data is aggregated over a 24-hour period; the data does not distinguish peak vs. non-peak periods.

Table 1 – Analysis of Toll-Paying SOV Trips, 9/10/19 and 9/12/19

	NB		**SB**	
	Tue, 9/10	***Thu, 9/12***	***Tue, 9/10***	***Thu, 9/12***
Trips	16,999	17,110	22,648	22,055
VMT	163,601	160,234	225,132	208,972
Miles/Trip	9.62	9.36	9.94	9.48
Revenue	$46,660	$58,033	$52,137	$53,672
Rev/Trip	$2.74	$3.39	$2.30	$2.43
Rev/Mile	$0.285	$0.362	$0.232	$0.257
Thru Trips	2,618	2,702	4,808	4,372
Rev. from Thru Trips	$11,650	$12,475	$16,467	$19,466
%Thru Trips	15.4%	15.8%	21.2%	19.8%
%Rev from Thru Trips	25.0%	21.5%	31.6%	36.3%
>8-mile Trips	8,583	8,347	10,699	9,954
Rev. from >8-mile Trips	$32,911	$34,270	$34,166	$38,173
%Trips >8 miles	50.5%	48.8%	47.2%	45.1%
%Rev from >8-mile Trips	70.5%	59.1%	65.5%	71.1%

The following observations may be drawn from the table above:

- The average trip length on a daily basis is in the range of 9-10 miles. In other words, the average trip is about half the length of the facility.
- Long-distance trips through the entire corridor comprise about 15% of northbound trips and 20% of southbound trips. In other words, although through trips are a significant contributor to traffic on the Express Lanes, they are far from a majority.
- The key segment of trips to consider with respect to the proposed rate policy is *trips greater than 8 miles in length*. These are the trips whose fares would increase under the proposed policy, since these are the only trips whose fares would exceed the current limit of $8.00.
- As the data indicates, approximately half of all trips on the Express Lanes are greater than 8 miles in length. And these trips account for 60-70% of revenue currently collected on the Express Lanes.
- Therefore, the ability to increase the maximum toll rate provides SANDAG with the ability to better manage over half of the users of the Express Lanes. This should facilitate better operations, since price can now be more effectively used during peak travel times to influence the behavior of these users.
- This enhanced management tool could also result in increased revenue, since this group of users will likely be paying more during heavily-traveled peak periods.
- The improved ability to manage traffic should have a corollary benefit of reducing the frequency with which the lanes are forced into HOV ONLY mode.

Critical Factors, Variables, and Related Considerations

In addition to the performance measure impacts described above, there are other considerations related to these operational strategies. Implementation opportunities and challenges, impacts to existing policies, coordination with ongoing efforts, cost, technical aspects and the physical system, must be weighed in making the decision of which operational strategies best meet the needs of SANDAG's future system and its customers. The following describes these considerations.

Implementation Timeline

This study reviews three distinct operational strategies, which could be implemented simultaneously or could be phased or implemented independently:

- Strategy #1: Transponder for All
- Strategy #2: Change HOV Eligibility (HOV2+ to HOV3+)
- Strategy #3: Increase Maximum Toll

All three operational strategies will directly and visibly impact SANDAG's customers. As such, SANDAG is encouraged to consider implementing these strategies simultaneously for the following reasons:

- SANDAG can optimize the outreach efforts and changes to the roadway signage by consolidating the changes into one message.
- These policy changes could result in some negative customer feedback. Industry experience has shown that combining policy change messaging with positive outreach (e.g. promotions, toll credits to offset the transponder deposit cost, etc.) has served to mitigate this to some extent.
- Consolidation of the changes will allow SANDAG to limit the required adjustments to call center operations to accommodate the anticipated spike in customer contact to one event, rather than three separate events over a span of time.

Implementation of these three operational strategies could begin immediately upon approval by SANDAG's Board of Directors. Timing would need to be coordinated with the ongoing Back Office System (BOS) Project and the Roadway Toll Collection System Project. For example, AVI readers configured to read 6C transponders must be installed, 6C transponders should be procured, and changes to notice text and other customer communications would need to be developed and provided to the BOS vendor. It is not likely that approval and required updates could be made in time for Phase 1 of the BOS go-live, so it is recommended that SANDAG work towards implementation of these policies in coordination with the Phase 2 go-live.

Required Back Office System and Operational Changes

Changes to the tolling policies can impact both the BOS and day to day operations of the BOS and Customer Service Center (CSC). System changes are expected to consist of relatively minor configuration changes requiring minimal effort and cost. Operational changes could consist of simple changes in processes/scripts for CSRs or could require additional staffing to support increased call volumes and/or production requirements.

Any of the potential toll policy changes would require some modification to the configuration of the BOS. Requiring all customers to have a transponder would require the violation processing be "turned on" and tested for the I-15 corridor. The notice functionality exists, modifications would just need to be made to

enable violations for vehicles travelling without a valid transponder. The functionality for the system to obtain and process information about which switch setting the transponder was in for each transaction would also be required.

The more noticeable impacts of these policy changes will likely be to operations. Some of these operational impacts will be short term, while others will result in ongoing needs. For example:

- While the new BOS will provide improved self-service options (i.e. IVR and website), the introduction of violations for customers who do not have a transponder could require increased staffing to accommodate the increased violation volumes. The increase in violations could impact call volumes, which would result in the need for additional phone representatives. Any violation processing and phone representative staffing increases would be long term.
- Changes to the transponder and HOV requirements as well as the maximum toll rate will likely result in a spike in calls to the CSC for a short period of time. SANDAG will need to staff up for this expected call increase. SANDAG will also need to consider their stance on these customers who call, with complaints about the changes. A "grace period" or first-time violator policy, similar to the policy in place on SR 125, could be established to show good will to customers who did not understand the new policies, resulting in a penalty being assessed.
- Transponder management will also be impacted by the policy changes. If transponders are required for all vehicles, SANDAG will also need to decide the strategy for occupancy declaration (e.g. switchable transponders, self-declaration online, or static declaration). This decision will determine which type of transponders will be used and how much inventory of each transponder type is needed. If the decision is to use switchable transponders, SANDAG will need to develop a recall/swap program for its current customers. SANDAG will also need to decide whether any promotions will be offered in coordination with the shift to requiring transponders for all (e.g. toll credits).

Required Roadway System Changes

In addition to the access changes discussed previously, there are other physical changes that may need to occur to accommodate the proposed policy changes. Current roadway signage provides information regarding transponders, HOV requirements and the maximum toll rate, therefore, changes to any of the policies would require updates to these signs. The roadside toll collection system would require minor configuration changes to accommodate the transponder, HOV and max toll rate changes, as these would all impact the fully formed transaction that is sent to the BOS. With the implementation of transponders for all, SANDAG will need to adjust the enforcement beacon configuration settings to provide visual indication of the vehicle's switch setting to enable enforcement by California Highway Patrol (CHP). Finally, the increased restrictions and cost associated with these policies may encourage more "cheaters." Therefore, SANDAG may want to consider additional physical changes to the roadway system to deter such violating (e.g. adding physical barriers where they do not exist, increasing manual enforcement, automated occupancy enforcement).

Procedures and Required Approvals for Policy Changes

At a state level, SANDAG will need to comply with the California Vehicle Code as it relates to toll operations. The code currently serves facilities with a variety of toll policies, including the transponder and HOV policies

evaluated in this study. Therefore, the code will serve any of the potential policy changes being studied by SANDAG.

At an agency level, SANDAG does not currently have a document which details the agency's policy on toll operations with details such as HOV thresholds, maximum toll rates or transponder requirements. To encourage operational transparency and ensure policies are not a risk for frequent changes which might impact the customer, it is recommended that these details be recorded for Board approval.

Factors Impacting Costs

The costs associated with implementing these policy changes are related to the items discussed in the previous sections. Implementing these policies simultaneously, would avoid duplication of efforts. The following bullets summarize the key factors impacting operational, staffing, and roadway costs as part of implementing the proposed policies.

- Factors Impacting Operational Costs
  - Minor BOS configuration
  - Procuring new transponders to be distributed to all customers (including those that were traditionally non-tolled users of the system)
- Factors Impacting SANDAG Staffing and Resources
  - Updating of all customer communication materials, business rules, website, etc.
  - Development and implementation of a transponder recall/swap program
  - Increase operations staffing to manage transponder inventory
  - Increase operations staffing to accommodate additional violation processing
  - Increase enforcement to mitigate potential for additional "cheaters"
- Factors Impacting Roadway Costs
  - System configuration updates, such as toll pricing rules and enforcement beacons messaging
  - Roadway signage changes

The table included in Attachment 1 summarizes the various implications of the policy changes being considered for the SANDAG I-15 Express Lanes.

Other Considerations

Implementing any of these policy changes will require SANDAG to clearly communicate the impacts to its customers, partners and other key stakeholders in the region. SANDAG's CSC should communicate with its customers by email or letter to notify them of any new transponder or HOV eligibility requirements. SANDAG should also conduct a marketing and outreach campaign to inform existing HOV customers who may not already have a transponder or have a FasTrak account with SANDAG. The marketing and outreach campaign should implement a strategy that integrates both existing FasTrak and HOV customer communications. For example, public events such as open-house and information kiosks could be installed near customer service centers stores and in locations convenient for targeted audiences. These events could be staffed and resourced to address all HOV and general FasTrak and I-15 Express Lanes questions and concerns.

It is important to note that, of the toll-paying users of the I-15 Express Lanes, not all are SANDAG FasTrak customers. In fact, over the course of a typical week, non-SANDAG customers (that is, customers whose transponder is based in some other agency within the California Toll Operator's Committee, or CTOC) account

for **about two-thirds** of all transponder transactions and **nearly 80%** of all users. Therefore, SANDAG's CSC will also need to make a concerted effort to communicate with its partners in CTOC. Any successful rollout of policy changes will depend on effective communication with all affected parties.

Moreover, if the SANDAG CSCs are successful in increasing the overall share of SANDAG FasTrak users, then the benefits are likely to be even more significant. This is because SANDAG FasTrak users tend to travel more frequently than other CTOC FasTrak users (in terms of trips per week), and their trips encompass more transactions per trip compared to other CTOC FasTrak users.

Conclusions

Work performed under Task 2 defined a vision, goals, and objectives for this study. Operational performance measures were established that provide SANDAG a means to evaluate how well the current facility and associated operational constraints achieve this vision, goals and objectives.

Vision

Under Task 2 of this study, the I-15 Corridor Management Team (CMT) defined a vision for the corridor. The CMT's vision includes a world class transportation facility that:

- Provides safe, reliable, predictable commute for I-15 Express Lanes customers;
- Provides easy to use travel options without barriers that meets the needs of today while also sustaining future growth and evolution in travel options;
- Has regionally consistent business rules and operating policies;
- Is aligned with Caltrans' & SANDAG's Mission and Vision;
- Strengthens successful partnerships with SANDAG, Caltrans, MTS and other stakeholders;
- Is a model for other Express Lanes corridors in the region; and
- Complements I-15 General Purpose Lane operations.

The operational strategies evaluated under Task 3 were selected based on the current express lane operational trends in California. Implementing these operational strategies would align the I-15 Express Lanes business rules with those currently in operation in Los Angeles County, Orange County, and Riverside County, as well as other facilities planned and in operation in both Northern and Southern California. In addition, these operational strategies would provide the tools necessary to provide and maintain reliable and predicable travel times in the I-15 Express Lanes as the region continues to grow and provide SANDAG and Caltrans a model that could be applied on other corridors in the region.

Goals & Objectives

Our analysis enables us to evaluate some, but not all, of the CMT's Goals and Objectives. Those that are pertinent to the analysis are included in the table below.

Goals & Objectives		Impact of Proposed Strategies
Goals	Balance capacity and demand to serve customers who pay tolls as well as carpoolers and transit customers who are offered discounted tolls	The analysis indicates that the proposed strategies can be effective at managing demand in the Express Lanes. This in turn preserved capacity within the Express Lanes, ensuring a reliable trip for all users (SOV, HOV, and transit).
	Generate sufficient revenue to sustain I-15 Express Lanes operations	As indicated by Performance Measure #14, the proposed strategies are projected to increase Express Lanes revenue. This in turn will enhance the ability to sustain operations of the I-15 Express Lanes.
	Provide equal access to all customers	The "Transponders for All" strategy has been shown to reduce violations. In this way, it helps to providing more consistent enforcement of those driver that wish to violate. The "Change HOV Eligibility" strategy—when separated from the requirement to have a transponder—tends to encourage violations and therefore does not support the goal of providing equal access to all customers.
	Equally enforce the toll policy across all travel choices	Under the current toll policy, CHP manually enforces the HOV eligibility policy and SANDAG enforces the toll payment policy. The "Transponders for All" strategy broadens SANDAG's ability to enforce its toll policy by expanding the share of users that have a valid transponder. The "Change HOV Eligibility" strategy does not assist with this goal since it is assumed transponders would not be required for all vehicles.
	Enhance corridor management and operations	SANDAG's ability to manage the corridor is directly related to two factors: (1) the number of users that are impacted by a particular toll rate adjustment; and (2) the magnitude of the prescribed toll rate adjustment. • The "Change HOV Eligibility" strategy expands the number of users impacted by a change in the toll rate, since this strategy applies the toll rate to all vehicles have 2 or fewer occupants. • The "Increase Maximum Toll" strategy strengthens the ability to manage operations by enabling higher toll rates to be charged during peak travel periods.
Objectives	Optimize and maintain I-15 Express Lane trip reliability	The analysis indicates that the "Transponder for All" and "Change HOV Eligibility" strategies both improve the ability to manage demand and reduce Express Lanes usage. This in turn will tend to improve trip reliability. Additionally, the "Increase Maximum Toll" strategy enhances the ability to charge appropriately-high tolls during peak periods as a demand management tool. This will

		also improve the reliability of travel in the I-15 Express Lanes.
	Reduce I-15 corridor (GP and EL) person and/or vehicle delay	Performance Measures 10 & 11 demonstrated that the proposed strategies will improve speeds and reduce travel times in the Express Lanes. This in turn suggests a reduction of EL delay. On the other hand, Performance Measures 12 & 13 demonstrated that the proposed strategies will tend to reduce speeds and increase travel times in the GP Lanes. This suggests that GP delays will tend to increase. In short, the proposed strategies will likely reduce peak-period delays in the EL at the expense of conditions in the GP lanes. In off-peak periods, the changes will be less significant.
	Improve I-15 corridor (GP and EL) person and/or vehicle throughput	As Performance Measures 1, 2, and 5 indicate, the proposed strategies will tend to reduce both the vehicle throughput and the person throughput in the Express Lanes. These measures are more effective at managing demand (and therefore improving operations) than they are at increase EL throughput. The strategies therefore tend to increase person and vehicle throughput in the GP lanes, to the extent that the GP lanes can handle the additional volume.
	Improve efficiency in the Express Lanes	The proposed strategies improve efficiency in terms reducing traffic to a level that is more manageable. However, the strategies will *not* improve efficiency in terms of the average occupant per vehicle, since both strategies tend to decrease the share of vehicles with 2 or more occupants.

Attachment 1: Critical Factors, Variables, and Related Considerations Summary

Strategy	Phasing/Timing	Required BOS/Operations Changes	Required Roadway System Changes	Required Policy Changes	Cost Impacts
Strategy #1: Transponder for All (transponders required for all customers)	Policies should be changed at once to minimize customer impact and reduce associated outreach efforts and required changes to communications materials and signage. Coordinating with the BOS go-live (Phase 2) will provide some efficiencies regarding changes to the system, notices, staff training, etc.	• System configuration to provide process for violations on I-15 (including adding the switch setting to the transaction information, flag to send notice for no transponder, development of new notices, etc.) • Update of necessary customer notifications and communication materials • Increased violation processing • Consider "grace period" for violators • Define and establish transponder plan for promotion/distribution	• System configuration changes • Signage change • Consider additional physical barriers to mitigate potential for additional "cheaters"	• Submit request for change to SANDAG Board for Approval • Update customer agreement to address transponder setting • Coordinate changes with CTOC for inclusion in ICD	• Provide transponders to all customers • Staff time to update BRs, website, customer notifications, etc. • Roadway signage changes • Increase Ops staffing to accommodate additional violation processing • Increased enforcement to mitigate potential for additional "cheaters"
Strategy #2: Changes HOV Eligibility Requirements (HOV 2+ changed to HOV 3+)		• Minimal system configuration • Update of necessary customer notifications and communication materials • Additional calls to CSC post implementation • Consider "grace period" for violators • Define and establish transponder swap/recall program • Create internal policy for disputing occupancy switch setting	• System configuration changes • Signage changes • Consider additional physical barriers to mitigate potential for additional "cheaters"	• Submit request for change to SANDAG Board for Approval • Coordinate changes with CTOC for inclusion in ICD	• Staff time to update BRs, website, customer notifications, etc. • Roadway signage changes • Increased enforcement to mitigate potential for additional "cheaters"
Strategy #3: Increase Maximum Toll (increase above current $8.00)		• Minimal system configuration • Update of necessary customer notifications and communication materials • Additional calls to CSC post implementation	• System configuration changes • Consider additional physical barriers to mitigate potential for additional "cheaters"	• Submit request for change to SANDAG Board for Approval • Coordinate changes with CTOC for inclusion in ICD	• Staff time to update BRs, website, customer notifications, etc. • Increased enforcement to mitigate potential for additional "cheaters"

APPENDIX H: I-15 EXPRESS LANES OPERATIONAL STUDY SKETCH LEVEL WORK PLAN TECHNICAL MEMORANDUM

To: Ryan Ross, SANDAG

From: Will Allen, HNTB

Date: July 6, 2020

Subject: I-15 Express Lanes Operational Study Sketch Level Work Plan Technical Memorandum

Purpose

The purpose of this memorandum is to present a sketch level work plan towards the implementation of operational strategies identified in this I-15 Express Lanes Operational Study for further consideration. The memo will summarize the key activities and timelines that are recommended as next steps to be carried out as part of this and a future study.

The contents of this memo will be included in the Final I-15 Express Lanes Operational Study and associated executive summary and presentations to be delivered under Task 4.

Background

HNTB recently completed an analysis that concluded three operational strategies have potential to benefit the operations of the I-15 Express Lanes, including:

- **Strategy #1 – Transponder for All**. This strategy requires all users of the Express Lanes (EL) to have a transponder, regardless of the number of occupants.
- **Strategy #2 – Change HOV Eligibility**. This strategy increases the required number of occupants (for toll-free travel) from HOV2+ to HOV3+.
- **Strategy #3 – Increase Maximum Toll**. This strategy increases the maximum toll for any trip on the I-15 Express Lanes above the current $8.00 maximum toll.

Additional information on these operational strategies is provided in the *Operational Strategy Performance Findings Technical Memorandum* developed under Task 3.

Sketch Level Work Plan

Before any of these operational strategies can be implemented, it is recommended that SANDAG conduct additional analysis, perform supplementary stakeholder coordination, and seek required approvals. The following table is a recommended Sketch Level Work Plan for implementing any of these operational strategies. The Sketch Level Work Plan includes a sequence of activities divided into four steps:

1. Determination of Operational Strategies: Includes four phases of activities necessary to determine which operational strategies best align with the I-15 vision, goals, and objectives and creating a detailed implementation plan for the recommended operational strategies.
2. Approvals and Procurement: Includes seeking necessary stakeholder approvals and procuring implementation services.
3. Operational Strategy Implementation: Includes the necessary system and infrastructure updates to implement the operational strategies as well as stakeholder training and community outreach.
4. Performance Monitoring: Includes operational monitoring and evaluation of impacts to the defined I-15 performance measures.

Task No.	Task Name	Task Description	Months	Predecessor Task	Task Assignment
1.0	**STEP 1**	**DETERMINATION OF OPERATIONAL STRATEGIES**			
1.1	**Phase 1**	**I-15 Express Lanes Operational Study (Phase 1)**			
1.1.1	**Final Report**	Prepare and submit Final Report summarizing Phase 1 for SANDAG approval.	2	N/A	HNTB
1.1.2	**SANDAG Board Approval of Further Study**	Obtain SANDAG Board Approval to study implementation of recommended operational strategies. Using the Executive Summary, Report, and Presentations developed under Task 4 of this study, SANDAG staff will present the operational benefits, impacts, and implementation plan associated with each operational strategy and seek approval to implement these strategies.	2	SANDAG Approval of Final I-15 Express Lanes Operational Study – Final Report (Task 1.1.1)	SANDAG Staff
1.2	**Phase 2**	**I-15 Express Lanes Operational Study (Phase 2)**			
1.2.1	**Social Equity Heat Mapping Analysis**	Evaluate existing conditions of Social Equity and operational characteristics in the corridor to identify any potential impacts to communities of concern. Cataloguing and mapping these characteristics will determine whether further study is needed to evaluate severity, proportionality, and ultimately mitigations. This task includes four primary subtasks.	3	SANDAG Board Approval of Further Study (Task 1.1.2)	HNTB
1.2.1.1	Social Equity Analysis Methodology Memorandum	The study team will write a memorandum detailing the methodology of the social equity study. SANDAG review and guidance will help refine the methodology to meet SANDAG's objectives.	1.5	SANDAG Board Approval of Further Study (Task 1.1.2)	HNTB
1.2.1.2	Geographic and Demographic Analysis	The study team will use US Census data to determine the existing demographic composition of the study area according to SANDAG Communities of Concern and FHWA demographic criteria of Social Equity. The study area will be divided into sub-areas to facilitate accurate comparisons to transportation data. Then, based on the study area demographic composition, the sub-areas will be categorized by level of Social Equity concentration. These will be mapped onto an aggregate Social Equity overlay and unique overlays per Social Equity category.	1.5	Social Equity Analysis Methodology Memorandum (Task 1.2.1.1)	HNTB
1.2.1.3	Literature Review	The study team will review SANDAG Planning and Environmental documents, state and federal guidance, and applicable national peer-organization studies to refine impact and proportionality criteria, public involvement needs, and documentation.	1.5	Social Equity Analysis Methodology Memorandum (Task 1.2.1.1)	HNTB

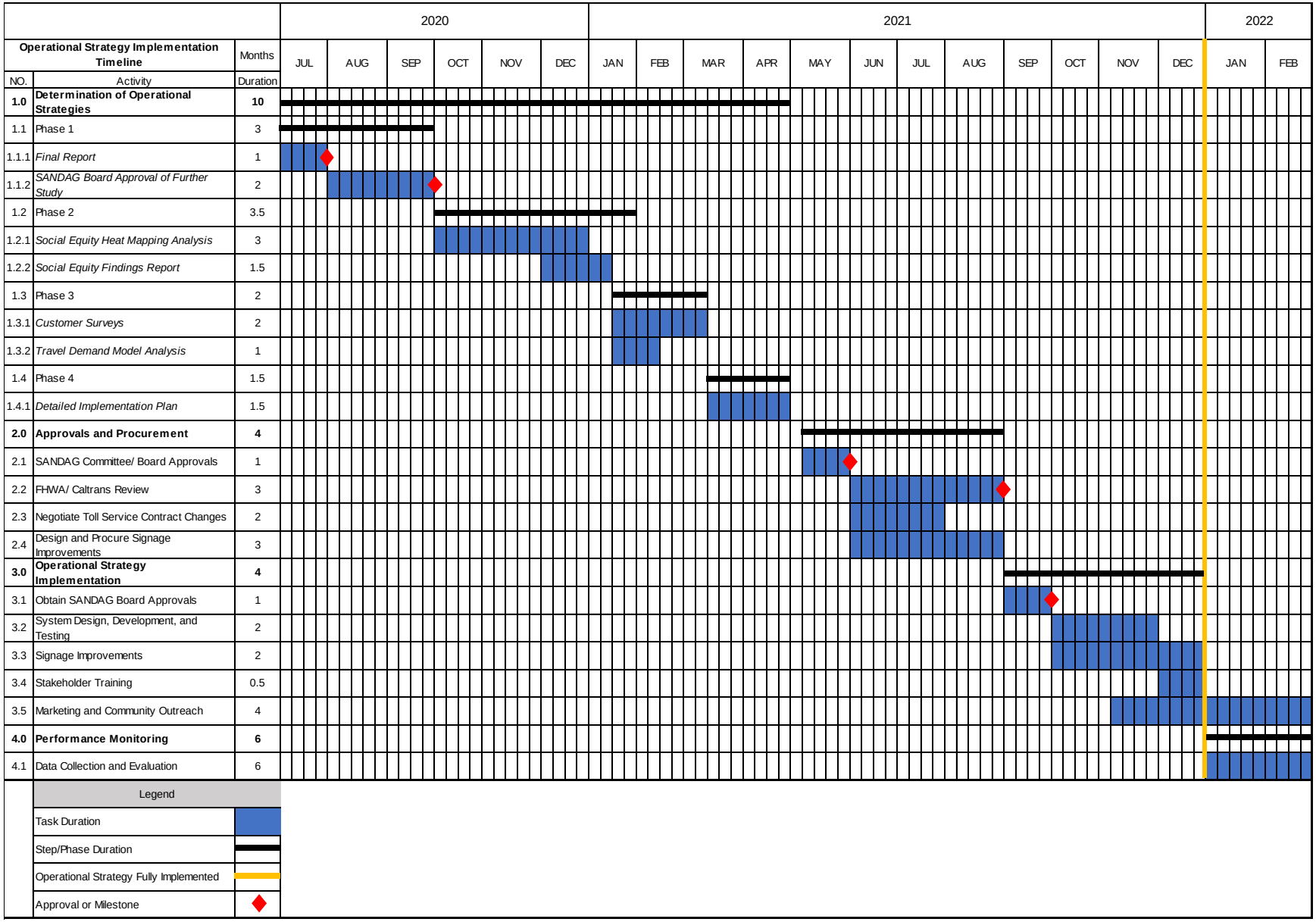
Task No.	Task Name	Task Description	Months	Predecessor Task	Task Assignment
1.2.1.4	Strategy Data Analysis	The performance measures identified in the Task 3 Operational Strategy Performance Findings Technical Memorandum will be evaluated for potential Social Equity impacts according to SANDAG, Caltrans, FHWA, and Title VI requirements. Those identified will be used to determine whether operational changes have potential to cause adverse impacts to users of Social Equity groups. Map overlays will be created to depict the performance measures existing and post-implementation of the operational strategies. A visual comparison of these changes related to the Social Equity maps will indicate impact severity and proportionality, and whether further study is necessary (i.e. Social Equity Impacts Assessment).	1.5	Social Equity Analysis Methodology Memorandum (Task 1.2.1.1)	HNTB
1.2.2	**Social Equity Findings Report**	Study findings will be recorded in a Social Equity Findings Report for submission to SANDAG for review and approval.	1.5	Social Equity Heat Mapping Analysis (Task 1.2.1)	HNTB
1.3	**Phase 3**	**I-15 Express Lanes Operational Study (Phase 3)**			
1.3.1	**Customer Surveys**	Findings from Social Equity Heat Mapping Analysis will inform recommendations for public involvement activities to incorporate community feedback in the final operational strategy recommendations. The Social Equity Findings Report should be updated with survey results.	2	Social Equity Heat Mapping Analysis (Task 1.2.1)	Not yet assigned
1.3.2	**Travel Demand Model Analysis**	Using readily available input and output data from SANDAG's travel demand model, the team can estimate future EL and GP trip origin and destinations at the study's sub-areas. This, coupled with a select link analysis, can provide insight into users' experience over time to understand lasting effects of the recommended operational strategies. Social Equity Findings Report should be updated with analysis results.	1	Social Equity Heat Mapping Analysis (Task 1.2.1)	Not yet assigned
1.4	**Phase 4**	**I-15 Express Lanes Operational Study (Phase 4)**			
1.4.1	**Detailed Implementation Plan**	Based on the results of the Social Equity Findings Report, develop a Detailed Implementation Plan that defines SANDAG's process to implement the SANDAG's preferred operational strategies. The Detailed Implementation Plan will include a detailed schedule of activities, planned stakeholder coordination, a marketing and outreach strategy, mitigation strategies resulting from social equity study, a plan for roadway signage improvements, a technology and systems analysis and	1.5	Social Equity Findings Report (Task 1.2.2)	Not yet assigned

Task No.	Task Name	Task Description	Months	Predecessor Task	Task Assignment
		upgrade plan, a data collection and evaluation plan, an implementation cost estimate, and an operational readiness assessment.			
2.0	**STEP 2**	**APPROVALS AND PROCUREMENT**			
2.1	**SANDAG Committee/ Board Approvals**	SANDAG Staff will present the results of the Social Equity Analysis and Detailed Implementation Plan and seek approval to coordinate with oversight agencies and request approval to implement the operational strategies.	1	Social Equity Findings Report (Task 1.3) Detailed Implementation Plan (Task 1.6)	SANDAG Staff
2.2	**FHWA/ Caltrans Review**	SANDAG's approved Social Equity Findings Report will be reviewed by external stakeholders. If the Social Equity Findings Report identifies potential for adverse impact, FHWA/Caltrans may require further study efforts to make an impact determination.	3	Social Equity Findings Report (Task 1.3) SANDAG Committee/Board Approvals (Task 2.1)	SANDAG Staff
2.3	**Negotiate Toll Service Contract Changes**	SANDAG Staff will negotiate changes to the existing Back Office System Agreement and Roadway System Agreement to include the functionality and services necessary to support these operational strategies.	2	SANDAG Board, Caltrans, and FHWA approval to implement operational strategies (Tasks 2.1 & 2.2)	SANDAG Staff
2.4	**Design and Procure Signage Improvements**	Design and procure a signage improvement project to update the roadway signage impacted by the operational strategies to be implemented (i.e. update signage to include requirements for FasTrak transponders).	3	SANDAG Board, Caltrans, and FHWA approval to implement operational strategies (Tasks 2.1 & 2.2)	SANDAG Staff
3.0	**STEP 3**	**OPERATIONAL STRAGEGY IMPLEMENTATION**			
3.1	**Obtain SANDAG Board Approvals**	SANDAG approval of Kapsch and ETAN contract amendments (if necessary) and signage improvement project.	2	Negotiate Toll Services Contract Changes and Procure Signage Improvements (Tasks 2.3 & 2.4)	SANDAG Staff
3.2	**System Design, Development, and Testing**	Back Office System vendor and Roadway System vendor will complete design and development as needed to implement operational changes and conduct testing to verify proper implementation.	2	SANDAG Board Approvals (Task 3.1)	Tolling Vendor; SANDAG Staff/Consultants
3.3	**Signage Improvements**	Signage contractor implements signage improvements.	3	SANDAG Board Approvals (Task 3.1)	Sign Contractor; SANDAG Staff/Consultants

Task No.	Task Name	Task Description	Months	Predecessor Task	Task Assignment
3.4	**Stakeholder Training**	SANDAG and its tolling vendors will conduct training to prepare the customer services center (CSC) and CHP to enforce the new business rules and communicate with customers.	1	Concurrent with System Design, Development, and Testing (Task 3.2)	Tolling Vendor; SANDAG Staff/Consultants
3.5	**Marketing and Community Outreach**	SANDAG will develop communications strategy and communicate new business rules to its customers.	4	Concurrent with System Design, Development, and Testing. (Task 3.2)	SANDAG Staff/Consultants
4.0	**STEP 4**	**PERFORMANCE MONITORING**			
4.1	**Data Collection and Evaluation**	Conduct a before and after data collection program to evaluate the impact of the operational strategies on the performance measures developed for the corridor.	6	Operational Strategy Implementation (Task 3.0)	SANDAG Staff/Consultants

Timeline

The following high-level timeline presents the sequence and approximate durations to carry out the Sketch Level Work Plan. The timeline shows the operational strategies could be fully implemented in approximately 17 months.



Operational Strategy Implementation Timeline		Months
NO.	Activity	Duration
1.0	**Determination of Operational Strategies**	**10**
1.1	Phase 1	3
1.1.1	*Final Report*	1
1.1.2	*SANDAG Board Approval of Further Study*	2
1.2	Phase 2	3.5
1.2.1	*Social Equity Heat Mapping Analysis*	3
1.2.2	*Social Equity Findings Report*	1.5
1.3	Phase 3	2
1.3.1	*Customer Surveys*	2
1.3.2	*Travel Demand Model Analysis*	1
1.4	Phase 4	1.5
1.4.1	*Detailed Implementation Plan*	1.5
2.0	**Approvals and Procurement**	**4**
2.1	SANDAG Committee/ Board Approvals	1
2.2	FHWA/ Caltrans Review	3
2.3	Negotiate Toll Service Contract Changes	2
2.4	Design and Procure Signage Improvements	3
3.0	**Operational Strategy Implementation**	**4**
3.1	Obtain SANDAG Board Approvals	1
3.2	System Design, Development, and Testing	2
3.3	Signage Improvements	2
3.4	Stakeholder Training	0.5
3.5	Marketing and Community Outreach	4
4.0	**Performance Monitoring**	**6**
4.1	Data Collection and Evaluation	6

Legend
Task Duration
Step/Phase Duration
Operational Strategy Fully Implemented
Approval or Milestone