STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT DOCUMENTATION PAGE

TR0003 (REV 10/98)

Lock Data on Form

1. REPORT NUMBER	2. GOVERNMENT ASSOCIATION NUMBER	3. RECIPIENT'S CATALOG NUMBER
CA17-3133		

4. TITLE AND SUBTITLE	5. REPORT DATE
Managing the Impacts of Freight in California	11/01/2017
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Genevieve Giuliano, Catherine Showalter, Quan Yuan, Rui Zhang	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NUMBER
University of Southern California METRANS Transportation Center Sol Price School of Public Policy Ralph and Goldy Lewis Hall, RGL 216 Los Angeles, CA 90089	11. CONTRACT OR GRANT NUMBER 65A0527 TO 035
12. SPONSORING AGENCY AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
California Department of Transportation Division of Research, Innovation and Systems Information 1727 30th Street - MS-83, PO Box 942873 Sacramento, CA 94273-0001	Final Report (January-November 2017) 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This research was motivated by new provisions in the 2016 Fixing America's Surface Transportation (FAST) Act, which require states to consider the impact of significant congestion or delays caused by the freight industry. Specifically, the FAST Act requires, “Consideration of any significant congestion or delay caused by freight movements and any strategies to mitigate that congestion or delay” (Federal Register, 81 (199), 10/14/16, 71185). The purpose of this research is to generate recommendations on the most effective strategies for reducing freight related congestion and its impacts. These recommendations will be considered for inclusion in the California Freight Mobility Plan (CFMP) 2019 version to comply with FAST Act requirements.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Freight; California; FAST Act;	No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161

19. SECURITY CLASSIFICATION *(of this report)*	20. NUMBER OF PAGES	21. COST OF REPORT CHARGED
Unclassified.	86	None.

DISCLAIMER STATEMENT

Final Report

Managing the Impacts of Freight in California

Contract 65A0527
Task Order 035
National Center for Sustainable Transportation

January - November 2017

Genevieve Giuliano
Catherine Showalter
Quan Yuan
Rui Zhang

Sol Price School of Public Policy
University of Southern California
Los Angeles, CA

Disclaimer Statement

"The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the STATE OF CALIFORNIA or the FEDERAL HIGHWAY ADMINISTRATION. This report does not constitute a standard, specification, or regulation."

Acknowledgement

This research was supported by the California Department of Transportation under the National Center for Sustainable Transportation university transportation center program. The support and assistance of the Caltrans Office of Freight Planning are gratefully acknowledged. All errors and omissions are the responsibility of the authors.

Table of Contents

Table of Tables

Table of Figures

Chapter 1: Introduction

With annual gross domestic product (GDP) of more than 2.4 trillion dollars, the State of California plays a major role in the nation's economic growth and international trade. It is the largest state economy in the US and accounts for about 14% of US GDP. Tons of goods are moved into California every day through its busy seaports, airports and borders. Some of these goods are consumed locally, while others are processed and transshipped to other states and countries. To ensure the efficiency and reliability of freight movement, California has invested a great deal in building and maintaining its freight infrastructure, but these investments are far outpaced by the rapid growth in both passenger and freight demand. The result is increasing congestion, especially at bottlenecks where congestion and delays are severe.

This research was motivated by new provisions in the 2016 Fixing America's Surface Transportation (FAST) Act, which require states to consider the impact of significant congestion or delays caused by the freight industry. Specifically, the FAST Act requires, "Consideration of any significant congestion or delay caused by freight movements and any strategies to mitigate that congestion or delay" (Federal Register, 81(199), 10/14/16, 71185). The purpose of this research is to generate recommendations on the most effective strategies for reducing freight related congestion and its impacts. These recommendations will be considered for inclusion in the California Freight Mobility Plan (CFMP) 2019 version to comply with FAST Act requirements.

The research project consisted of the following tasks: 1) describe current and expected impacts of freight, 2) review the 2014 California Freight Mobility Plan (CFMP), 3) conduct public outreach to inform stakeholders of the research and recommendations, 4) review and assess mitigation strategies, and 5) provide recommendations for the 2019 CFMP.

Describing the current and expected impacts of freight required the development of a method to identify freight impacts. Although there are several studies of freight bottlenecks and freight congestion, there is no prior research on identifying congestion *caused* by freight. The first task therefore develops a method for identifying congestion caused by freight and applies it to the two largest metro areas in California, Los Angeles and San Francisco, as well as the rest of the state. Our method estimates impacts on passenger vehicles, and provides descriptive information on impacts on other modes. Results of Task 1 are presented in Chapter 2.

The purpose of reviewing the 2014 CFMP was to examine the mitigation strategies presented in the plan, and to obtain data on forecasts of future freight demand. The CFMP does not include a forecast of future freight transportation demand sufficient to estimate impacts (e.g. a transport network forecast), nor is there statewide forecast data available from any other source. Therefore we do not discuss impacts of future freight demand. Results of Task 2 are presented in Chapter 3.

We conducted two webinars to inform stakeholders and elicit feedback on our method and recommendations. The webinars are described in Chapter 4. Our survey of mitigation strategies is based on the 2014 CFMP, as well as an international review of literature and best practices. Potential strategies and recommendations are presented in Chapter 5.

Chapter 2: Current and Expected Impacts of Freight

2.1. Background

The FAST Act specifically requires the identification of impacts *caused* by freight. Conventional methods of identifying freight congestion, such as identifying freight bottlenecks, focus on freight congestion, or the impacts of overall congestion on freight. For example, freight bottlenecks are often identified based on congestion bottlenecks, and then freight delay is calculated based on freight volumes. In this case we are interested in the opposite effect: Where are freight volumes high enough to significantly contribute to total congestion? Freight also has the potential to impose other delays, including vehicle delay at at-grade rail crossings and arterial delays around major freight generators. We need methods to identify these types of delays as well.

Caltrans and other public agencies in California have made efforts to identify freight bottlenecks and mitigate their impacts on the transportation system. For example, the 2013 San Joaquin Valley Interregional Goods Movement Plan predicts that increasing population and industry activities would lead to stronger competition between trucks and cars for limited roadway access, ending up with severe bottlenecks throughout the region by 2040. The 2014 San Francisco Bay Area Freight Mobility Study (SFBAFMS) uses the Caltrans Performance Measurement System (PeMS) and truck counts data to calculate daily hours of truck delay, and then identifies freeway corridors that experience the worst traffic congestion.

Research on freight impacts remains limited. First, there is no statewide assessment of freight bottlenecks due to the lack of data on traffic conditions and volumes across the state. Second, existing studies employed various methodologies for identifying freight bottlenecks, but the advantages and limitations of using these methodologies are largely unknown. Third, to our knowledge, there are no previous studies treating freight as the causal agent.

2.2. Purpose

This report aims to provide a statewide assessment of freight movement on traffic congestion. We distinguish between *freight bottlenecks* and *freight impact areas*. A freight bottleneck is a location where freight traffic is impeded; the emphasis of freight bottleneck studies is to reduce freight delay. Freight impact areas are locations where the concentration of truck traffic imposes delays on other traffic, and the emphasis is on mitigating these impacts.

We will compare methodologies used in previous studies and use those that most accurately measure freight-related congestion impacts. Based on the current condition of freight infrastructure in California, the report will primarily focus on the National Highway System and major arterial system. Two types of freight impact areas will be identified: 1) areas on the National Highway System, ranked by their severity of congestion and delays; 2) arterial areas, with relation to major freight facilities such as airport, seaports, intermodal terminals and border crossings. This systematic assessment of freight impact areas will help Caltrans and other public agencies better understand the performance of the state's freight infrastructure, and enable targeting policies to maintain a sustainable and efficient freight system.

2.3. Approach and Data

While there are a number of research reports on traffic congestion and freeway bottlenecks, the efforts on freight bottlenecks have been quite limited, even when we expand our scope to the entire country. We reviewed recent studies and selected three representative studies to discuss.

One of the early reports on this topic, "An Initial Assessment of Freight Bottlenecks on Highways," was performed by Cambridge Systematics (CS) for the Federal Highway Administration (FHWA) in 2005 (Cambridge Systematics and Battelle Memorial Institute, 2005). CS developed a Highway Truck Bottleneck Typology and applied it to the National Freight System. Bottlenecks were defined as "highway bottlenecks that serve high volumes of trucks" and they were categorized into four types: 1) Interchange capacity and other roadway capacity bottlenecks; 2) Lane-drop bottlenecks; 3) Signalized intersection bottlenecks; and 4) Steep-grade bottlenecks. As these bottlenecks were created for different reasons and conditions, CS used separate methods to identify them. For capacity bottlenecks, they conducted an automated scan of the FHWA Highway Performance Monitoring System (HPMS) Universe database and combined the results with questionnaire responses from all state departments of transportation. For other types of bottlenecks, CS scanned the HPMS Sample Database, which contained more detailed traffic information, and identified bottlenecks based on volume-to-capacity ratio or physical configuration of road segments (for instance, roadway sections with grades greater than 4.5% and more than a mile long). After these scans, CS applied truck volumes estimated from the Freight Analysis Framework (FAF) database and the HPMS Sample Database to calculate the truck hours of delay at the bottlenecks. The report is valuable given its pioneer work and the coverage of the entire country. There are, however, several limitations in its methodology, apart from those mentioned by the report itself (such as the simplification in calculating delay at interchange bottlenecks and delay caused by incidents and crashes; please refer to more details in Cambridge

Systematics and Battelle Memorial Institute, 2005, on pp. 4-7~4-9). First, the basic logic of identifying bottlenecks is questionable. The truck hours of delay were calculated after the identification of bottlenecks, suggesting that the identified bottlenecks were not selected based on truck-related congestion, but on indirect indicators like the V/C ratio. It is likely that some roadway segments with high truck delays were ignored in the first scan of bottlenecks. Second, the estimation of roadway capacity, truck volumes and truck delays depends on many assumptions and unknown parameters. It is difficult to replicate the analysis without the omitted information. Third, identified bottlenecks are point locations with no information on the spatial extent and direction of congestion.

The American Transportation Research Institute (ATRI) has issued a series of reports showing the nation's top truck bottlenecks (Short and Murray, 2014). By collecting and processing truck GPS data, ATRI quantified traffic congestion experienced by trucks at nationwide point locations. Note that in this report, bottlenecks were also defined as point locations where congestion occurs. The approach ATRI used is more explicit and duplicable. The five steps in this analysis are as follows:

1) identify study population through extraction of relevant commercial truck data during all weekdays of the studied year at 250 specific locations using an extensive truck GPS database;
2) apply data quality tools and techniques;
3) apply a four-step analysis process that utilizes vehicle time, date and speed information;
4) calculate total freight congestion values and ranking (congestion index); and
5) produce detailed congestion profiles of the 100 top ranked locations.

Instead of using truck delays to measure congestion impacts, ARTI defined a core index "total freight congestion value" and ranked bottlenecks in terms of this indicator. The methodology to calculate the "total freight congestion value" includes:

1) determine free flow speed;
2) determine average truck speed and the deviation from free flow speed (the MPH below free flow);
3) calculate hourly freight congestion value by multiplying the MPH below free flow by truck volume;
4) develop total freight congestion value by summing up all 24 hourly values of a day.

The total freight congestion value essentially measures the accumulation of the loss of speed by all trucks during the day at a certain point location. Although this indicator has little theoretical meaning, it is useful for evaluating how truck movement interacts with traffic congestion.

The 2014 San Francisco Bay Area Freight Mobility Study, on the other hand, provides some important thoughts on defining freight impact bottlenecks, even though freight bottlenecks were not a central focus of the report (Cambridge Systematics, 2014). Following the definition of PeMS database, the study identified highway segments with speeds less than 45 mph as bottlenecks and calculated daily hours of truck delay accordingly. While the approach seems relatively simple, some details in the results deserve our particular attention. First, the bottlenecks in the report are roadway segments, instead of point locations. In fact, a bottleneck, by the definition of FHWA, is "a localized section of highway that experiences reduced speeds and inherent delays due to a recurring operational influence or a nonrecurring impacting event."[1] All the studies mentioned above nonetheless defined bottlenecks as point locations, in most cases interchange locations. In fact, even at freeway interchanges, bottlenecks should have at least length and direction. The length of bottlenecks indicates the spatial extent of congestion, and the direction of bottlenecks shows the directional traffic flow. Point locations, however, do not contain this important information. Our daily experience also tells us that congestion does not occur at a certain point of a roadway, but on continuous segments of a roadway. Therefore, the definition of bottlenecks in the SFBAFMS is more accurate. Second, given that bottlenecks are identified as congested roadway segments, the length of a bottleneck could be incorporated into the measurement of freight congestion. The "hours of truck delay" used in the SFBAFMS effectively considers the length of bottlenecks and provides more information than the aforementioned indicator "total freight congestion value," which probably fails to distinguish short bottlenecks from long ones.

2.3.1. Methodology

The FAST Act requires that the *impact of significant congestion or delays caused by the freight industry* be described. Therefore, we define a **freight impact area** as ***a severely congested roadway corridor with high volumes of trucks***. Trucks, especially combination trucks, disproportionately contribute to traffic congestion, due to different performance characteristics (e.g. slower acceleration and deceleration, larger turning radius, etc.). Therefore, bottlenecks caused by freight movements on highways and arterial roads are likely to be located where congestion is heavy and the density of trucks is significant. Note that other freight modes such as

[1] Federal Highway Administration. Localized Bottleneck Reduction Program. See https://ops.fhwa.dot.gov/bn/lbr.htm

freight rail, or intermodal transshipping can result in congestion. While most of the existing studies generate estimates of congestion experienced by freight, our study stresses the role of freight in producing general traffic delays. For example, there are typically delays at terminal gates, but these do not affect general traffic, and hence are less important from the perspective of quantifying impacts of freight on general traffic.

An impact area could be a combination of continuous (linked) segments with different physical configurations (number of lanes, etc.). When identifying them, we focus on the most congested period of time during a day—PM peak hours. Although the highest volume of trucks may not occur in the PM peak, the impact of trucks on congestion is likely to be the highest. The significance of freight impact areas, which depends on both the severity of congestion and the volume of trucks, is measured by four indices: average peak hour freight congestion value (APHFCV), total peak hour freight congestion delay (TPHFCD), average peak hour all-vehicle congestion value (APHACV) and total peak hour all-vehicle congestion delay (TPHACD). We use APHFCV, which is adapted from the aforementioned ATRI approach, to identify the impact areas, and we use TPHACD to calculate total delay, our measure of impact.

It bears noting that we are not considering other types of impacts, such as the lack of capacity to respond to emergencies or unexpected events. The FAST Act mentions congestion explicitly, so we restrict our analysis to congestion impacts.

The calculation steps used to produce the average peak hour freight congestion value are as follows (see the Figure 2.3-1):

1) determine free flow speed for all segments;
2) determine truck speed during peak hours and the deviation from (truck) free flow speed;
3) develop peak hour freight congestion value for each segment;
4) select the segments above a predetermined threshold of peak hour freight congestion value;
5) if selected segments are located next to each other, combine them into roadway corridors;
6) calculate the average peak hour freight congestion value from the average values of peak hour freight congestion value among all roadway segments within each corridor.

The average peak hour all-vehicle congestion value (APHACV) is calculated following similar steps using all-vehicle volumes.

Step 1: Calculate $\boldsymbol{PHFCV = V_T * (S_{FF} - S_{AT})}$,

Where
$PHFCV = Peak\ Hour\ Freight\ Congestion\ Value$;
$V_T = Truck\ volumes\ during\ peak\ hours$;
$S_{FF} = Free\ flow\ speed\ (55\ mph\ for\ trucks)$
$S_{AT} = Average\ truck\ speed$

Step 2: Identify segments with PHFCV of at least *x*.

Step 3: If selected segments are adjacent, combine them.

Step 4: Calculate the APHFCV from the average values of PHFCV among all segments.

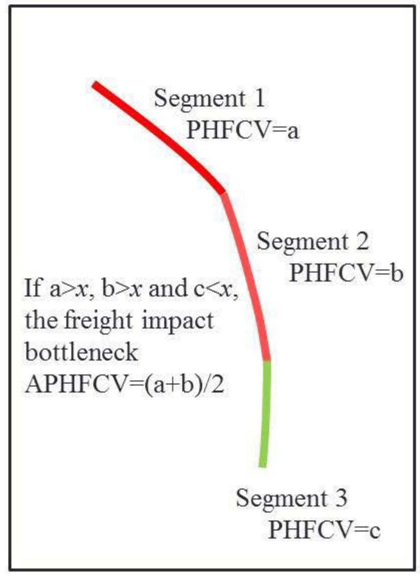

Figure 2.3-1 Steps for calculating average peak hour freight congestion value

The calculation steps used to produce the total peak hour freight congestion delay are shown in Figure 2.3-2. TPHACD is calculated the same way, using total vehicle volume rather than truck volume and private vehicle free flow speed.

Step 1: Calculate $\boldsymbol{PHFCD = V_T * (L/S_{AT} - L/S_{FF})}$,
Where
V_T = *Truck volume*
L = *length of segment*
S_{AT} = *Average truck speed*
S_{FF} = *Free flow speed (55 mph)*

Step 2: Identify segments with PHFCD of at least *y*.

Step 3: If selected segments are adjacent, combine them.

Step 4: Calculate the TPHFCD from the sum values of PHFCD among all segments.

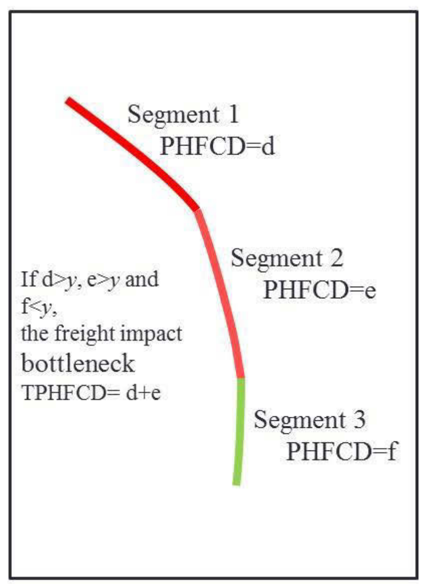

Figure 2.3-2 Steps for calculating total peak hour freight congestion delay

2.3.2. Data

Freight congestion problems are geographically concentrated. The Los Angeles Combined Statistical Areas (CSA) and the San Francisco CSA account for 70% of California's population[2], 72% of its employment[3] and 81% of its commodity flows[4]. The most congested roadways in California are also located in these two CSAs[5]. The two CSAs will include the vast majority of the most severe freight impact areas in California. Other freight impact areas in the rest of the state are likely to be located along major freight corridors near major cities.

In order to identify segment level bottlenecks associated with freight, we need truck volume and truck speed data on each segment. No such source of actual traffic flow data exists. For instance, the National Performance Management Research Data Set (NPMRDS) provides monthly updated passenger and freight vehicle travel data on the National Highway System. The data set contains the location information of each Traffic Message Channel (TMC), length of each TMC, and travel times for passenger vehicles and freight vehicles of each TMC. Based on the travel times for freight trucks, we can calculate the loss of speed because of congestion experienced by these vehicles. However, this data set does not contain any truck flow data, i.e. the number of trucks passing each TMC during each time period (or the "EPOCH" in the data set), making it insufficient for identifying freight impact areas within the framework of our methodology. On the other hand, truck flow data from sources such as Weigh-In-Motion (WIM) or PeMS are available only at the WIM or vehicle classification traffic sensor station locations on the highway network. Even if we could estimate truck volumes on each roadway segment through interpolation, the accuracy of the estimates would be questionable given the limited number of data points. Furthermore, none of these data sets provides traffic volumes and traffic counts on the arterial system. In many dense urban areas, the arterial system has long been severely congested due to intensive truck movement. Congestion associated with trucks on the arterial system should not be ignored in the statewide freight plan. We therefore use simulation model data for the regions of Los Angeles and San Francisco instead, which offers both truck volumes and truck speed on each roadway link. We use the baseline equilibrium assignments of heavy

[2] According to United States Census Bureau, Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2015 - United States -- Combined Statistical Area; and for Puerto Rico.
[3] According to 2014 County Business Patterns.
[4] According to 2012 Freight Analysis Framework, commodity flows originating from LA CSA and SF CSA in terms of dollar values account for 82% of the total flows of the entire state.
[5] According to American Transportation Research Institute, Congestion Impact Analysis of Freight-Significant Highway Locations - 2017.

duty trucks (HDTs) that are calibrated on actual data (including truck O-D surveys). For the rest of California, we use the PeMS data to identify station-based highway freight impact areas only. Please note that as the data sources used to identify bottlenecks are different across regions, the severity of these bottlenecks is comparable within each region but not comparable between regions. We calculate total congestion delay in all three regions, Los Angeles, San Francisco, and the rest of CA, but due to the different data sources and formats, we cannot draw any conclusions about specific levels of delay of an impact area in LA with another in SF.

We next describe the geographic composition of the two regions. Los Angeles-Long Beach-Riverside, CA CSA (Los Angeles CSA) consists of three MSAs, and five counties in total: Los Angeles-Long Beach-Santa Ana, CA MSA (which includes Los Angeles and Orange County); Oxnard-Thousand Oaks-Ventura, CA MSA (which includes Ventura County); and Riverside-San Bernardino-Ontario, CA MSA (which includes Riverside and San Bernardino County).

San Jose-San Francisco-Oakland, CA CSA (San Francisco CSA) consists of six MSAs, and eleven counties in total: Napa, CA MSA (which includes Napa County); San Francisco-Oakland-Fremont, CA MSA (which includes Alameda, Contra Costa, Marin, San Francisco, and San Mateo County); San Jose-Sunnyvale-Santa Clara, CA MSA (which includes San Benito and Santa Clara County); Santa Cruz-Watsonville, CA MSA (which includes Santa Cruz County); Santa Rosa-Petaluma, CA MSA (which includes Sonoma County); and Vallejo-Fairfield, CA MSA (which includes Solano County).

For the Los Angeles metro, we use the SCAG RTP/SCS (Regional Transportation Plan / Sustainable Communities Strategy) 2012 baseline travel model. The SCAG model is based on 4,109 TAZs and it spans six counties (Los Angeles, Orange, San Bernardino, Riverside, Ventura, and Imperial). The model network is very large and detailed: it has 68,389 links, which amount to 41,423 km of link length and 111,599 km of link lanes. For the San Francisco Bay Area, we use the 2013 RTP/SCS, model version 03, 2010 scenario, which reflects 2010 census results. The MTC model is based on 1,454 TAZs, and it spans 9 counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma). The MTC model is less detailed than the SCAG model; it consists of 24,545 links, 19,068 km of link length and 31,604 link lane-km, excluding dummy links. As far as we know, these two models are the only available regional transportation models in California that provide estimated truck volumes.

Using simulation data means that we are using recurrent congestion only. Congestion caused by accidents, closures, or other events are not included. Examining non-recurrent congestion would require accident and event data, as well as data on truck volumes, which as noted earlier is not available.

2.4. Results

2.4.1. Freight Impact Areas on the National Highway System

2.4.1.1. Los Angeles CSA

In the Los Angeles region, congestion is widespread throughout the highway system during PM peak hours (see Section 2.3.1 for a discussion on the selection of PM peak). General traffic congestion is extensive on the major freeways, especially I-405, I-5 and I-110. Considering truck volumes on the National Highway System, freight impact areas are concentrated on freight corridors connecting ports, intermodal terminals and warehousing clusters, such as I-710, I-10 and US-60. After calculating all four indices for all highway segments, we identify the top 15 freight impact areas, which are shown in Figure 2.4-1. The freight impact areas are ranked (by column) in the order of their total peak hour all-vehicle congestion delay in the figure.

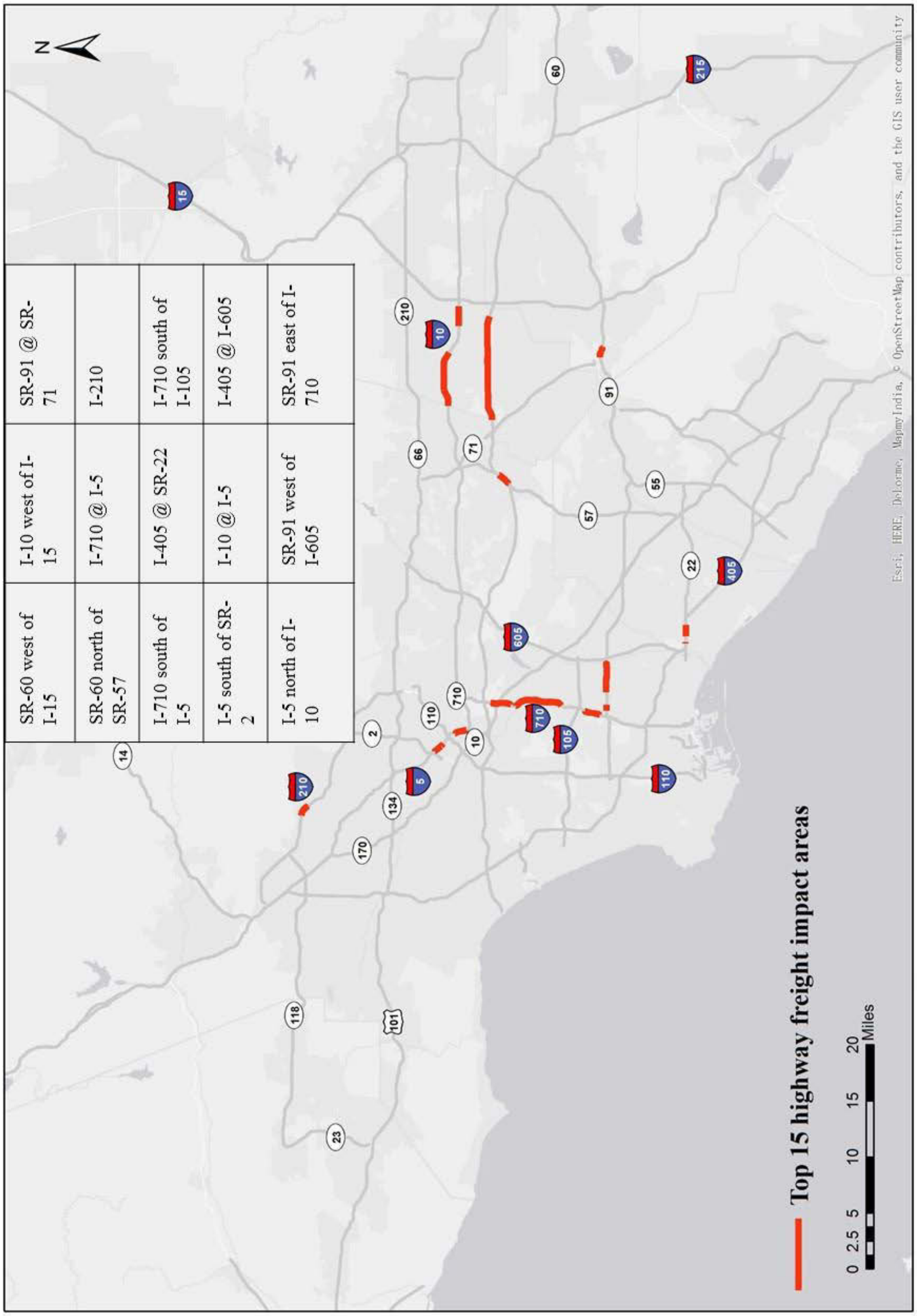

Figure 2.4-1 Top 15 freight impact areas on the National Highway System during PM peak hours in the Los Angeles region

Table 2.4-1 shows the descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the Los Angeles region. The longest freight impact area, the SR-60 west of I-15, is nearly 10 miles, and the average is a little over 2 miles. All the impact areas have relatively high volumes of trucks and shares of trucks. The average congestion speed of these freight impact areas is 18.6 mile/hour, reflecting the serious congestion that exists in the region. The combination of slow traffic speed and high traffic volumes generate large delays; an average of about 3600 vehicle hours for the daily PM peak. Vehicle hours of delay is overwhelmingly passenger delay, because even in high volume truck corridors passenger vehicles constitute most of the traffic.

Table 2.4-1 Descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the Los Angeles region

	Average	Minimum	Maximum
Length (mile)	2.24	0.11	9.95
Average total volume per direction during PM Peak	43,241	32,529	61,762
Average truck volume per direction during PM Peak	3,252	2,594	4,062
Average share of trucks	8.00%	4.38%	10.85%
Congestion speed (mile/hour)	18.61	8.10	29.93
Average peak hour all-vehicle congestion value (vehicle*mile/hour)	1,601,514	788,302	2,697,618
Total peak hour all-vehicle delay (vehicle*hour)	3,574.3	344.0	11,741.6
Average peak hour freight congestion value (truck*mile/hour)	113,528	85,395	125,044
Total peak hour freight delay (truck*hour)	285.0	20.4	1,103.7

We provide two examples to illustrate our results. Full details of each impact area are included in Appendix A, Table 1. Table 2.4-2 gives information on two impact areas, the I-710 at I-5, and SR 60 in the Ontario area, and Figure 2.4-2 shows their locations. These two impact areas have similar average truck volumes and average total volumes during the peak hours. I-710 at I-5 is more congested given its lower average speed. However, total delay experienced by all vehicles is much higher for SR-60 west of I-15, because its length is more than five times longer than the other impact area. These two impact areas are both in areas with high volumes of freight truck movement, but the density of the highway network varies across the two areas, making the spatial extension of congestion different. The continuous congestion along the SR 60 greatly contributes to the high all-vehicle delay. Comparatively, the overall delay is much lower for the impact area I-710 at I-5 even though congestion on the I-710 is more severe in terms of average traffic speed. This comparison between typical freight impact areas illustrates one of the merits of our approach—its effectiveness in identifying continuous congestion along highways.

Table 2.4-2 Description of two Los Angeles Region impact areas

	I-710 @ I-5	SR 60 west of I-15
Length (mile)	1.82	9.95
Average truck volume per direction during PM Peak	3,690	3,454
Average truck share	10.3%	9.4%
Average total volume per direction during PM Peak	36,276	36,745
Average speed (mph)	16	19
Total delay (vehicle*hour)	3,608	11,741

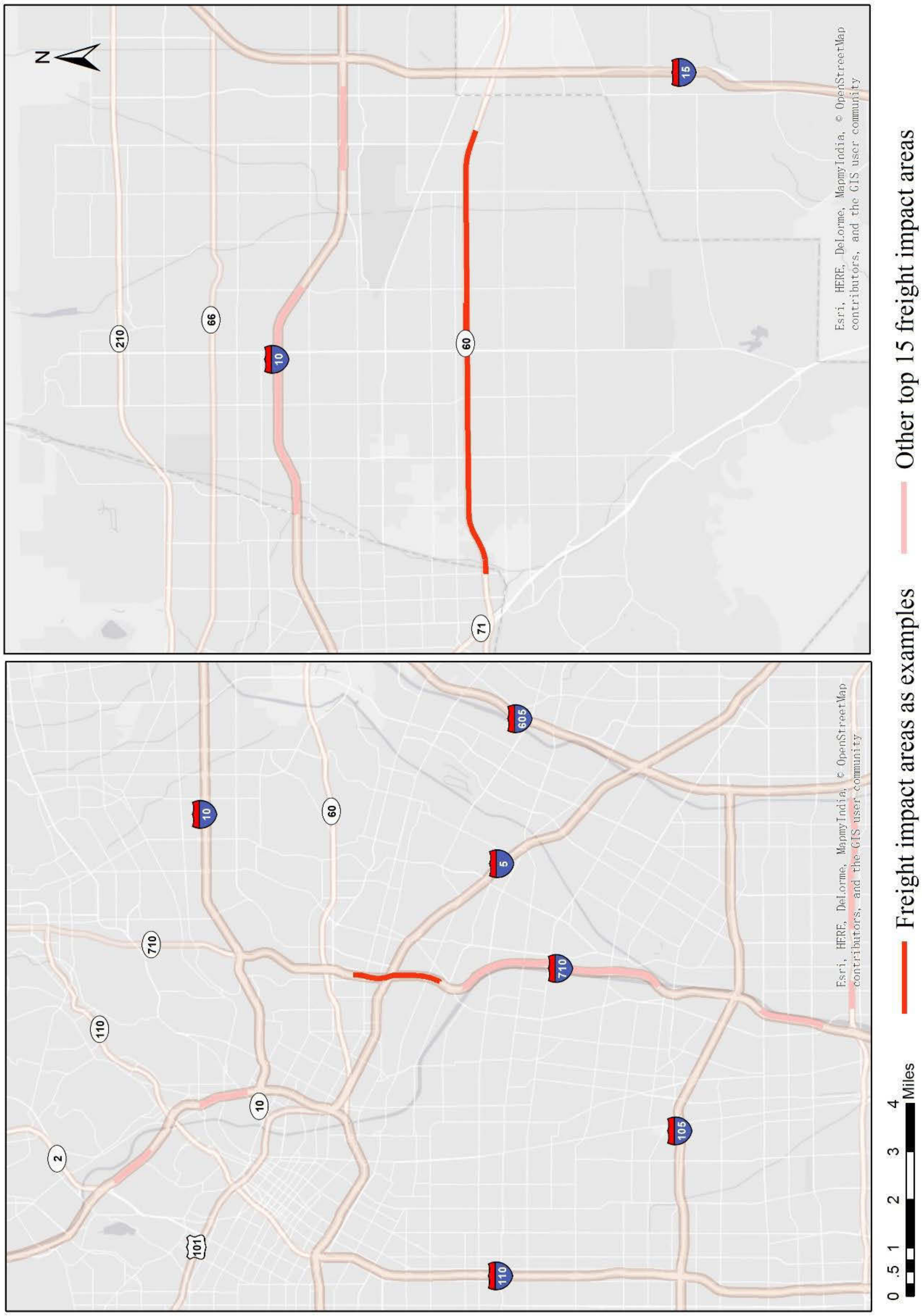

Figure 2.4-2 Map of two impact areas in the Los Angeles region, the I-710 at I-5 (left), and SR 60 in the Ontario area (right)

2.4.1.2. San Francisco CSA

The simulation model data suggests that PM peak congestion is less prevalent in the San Francisco region than in Los Angeles. We surmise that the difference is in part due to the different levels of aggregation of the models. However, it is also the case that Los Angeles has more congestion than San Francisco according to the Texas A&M Transportation Institute Congestion Index (Schrank, Lomax, and Eisele, 2011). We use the 2011 edition in order to be as close as possible to the model data years. Los Angeles ranked 3 and San Francisco ranked 7 among all metropolitan areas. Los Angeles experienced 64 hours of Yearly Delay per Auto Commuter, 28% higher than San Francisco.

Our results show that general traffic bottlenecks can be found on certain parts of interstate freeways, especially on the San Francisco Bay Bridge, downtown San Francisco, San Mateo, and San Jose. As in Los Angeles, freight impact areas are concentrated on freight corridors connecting ports, intermodal terminals and warehousing clusters, such as I-880, I-680 and US-101 (see Figure 2.4-3).

Full details on all 15 impact areas are available in Appendix A, Table 2. Table 2.4-3 shows the descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the San Francisco region. We can see from the table that the impact areas in San Francisco are on average shorter in length than those in Los Angeles. These impact areas also have relatively lower volumes of trucks and shares of trucks, but higher congestion speeds. Figure 2.4-4 and Table 2.4-4 provide two examples of the San Francisco region results, I-680 Fremont and I-80 San Francisco Bay Bridge. Compared to I-680 Fremont, I-80 SF Bay Bridge has higher average total volume and average truck volume during the peak hours while the average congestion level there is slightly lower. Given much larger spatial extent, I-80 SF Bay Bridge impact area also has a much higher total delay. This finding supports what we have found in Los Angeles: the overall severity of congestion in terms of total delay on the general traffic largely depends on the length, or the spatial extent of a freight impact area.

Table 2.4-3 Descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the San Francisco region

	Average	Minimum	Maximum
Length (mile)	1.59	0.13	4.73
Average total volume per direction during PM peak	28,564	18,401	40,924
Average truck volume per direction during PM peak	2,168	1,432	2,880
Average share of trucks	7.77%	5.07%	11.76%
Congestion speed (mile/hour)	31.81	21.80	45.00
Average peak hour all-vehicle congestion value (vehicle*mile/hour)	638,221	301,151	1,014,946
Total peak hour all-vehicle delay (vehicle*hour)	613.1	57.9	2,940.4
Average peak hour freight congestion value (truck*mile/hour)	47,932	28,093	65,722
Total peak hour freight delay (truck*hour)	45.9	5.1	190.4

Table 2.4-4 Description of two San Francisco Region impact areas

	I-680 Fremont	I-80 SF Bay Bridge
Length (mile)	0.92	4.73
Average truck volume per direction during PM peak	2,127	2,650
Average truck share	7.7%	6.5%
Average total volume per direction during PM peak	27,523	40,924
Average speed (mph)	23	25
Total delay (vehicle*hour)	622	2,940

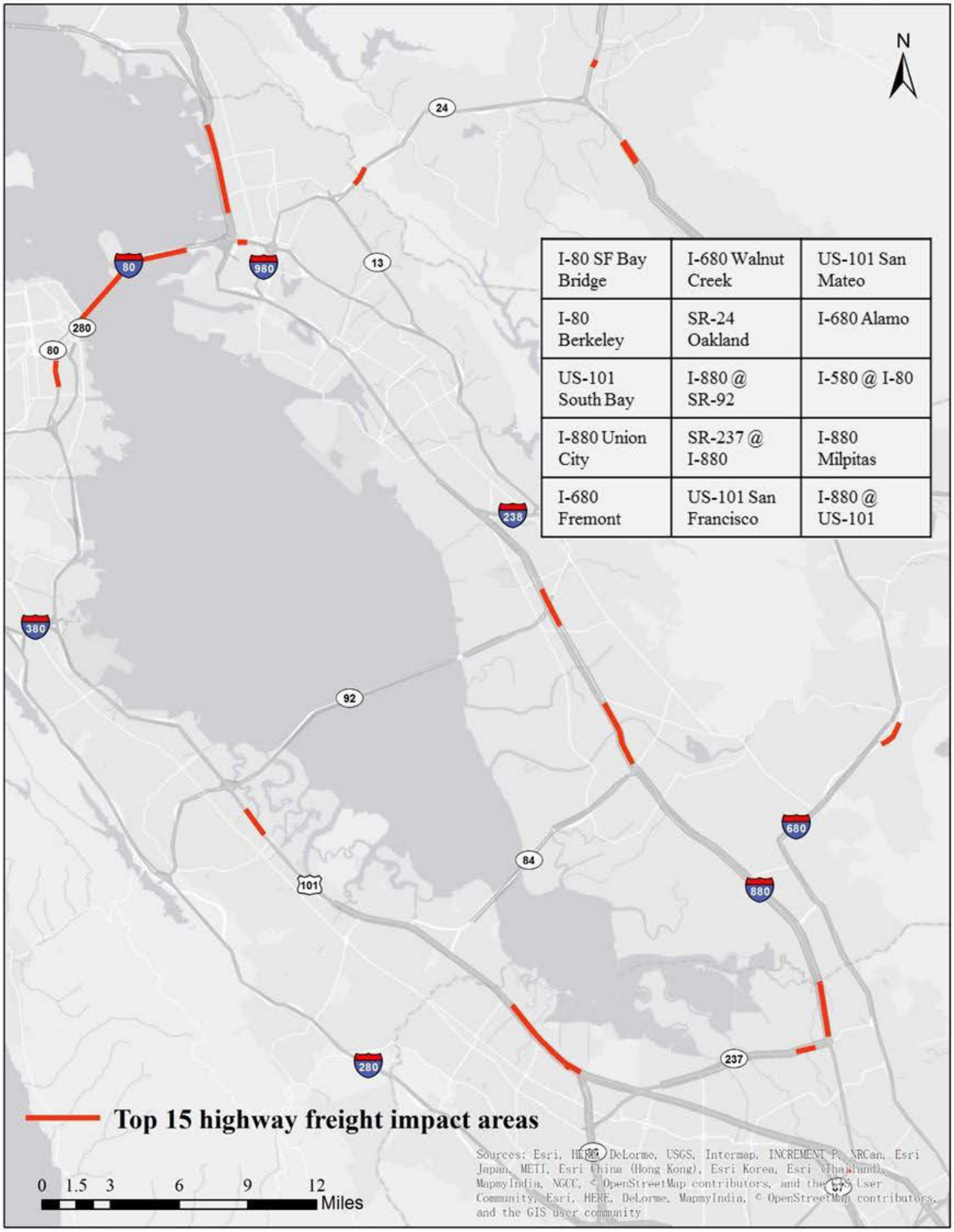

Figure 2.4-3 Top 15 freight impact areas on the National Highway System during PM peak hours in the San Francisco region

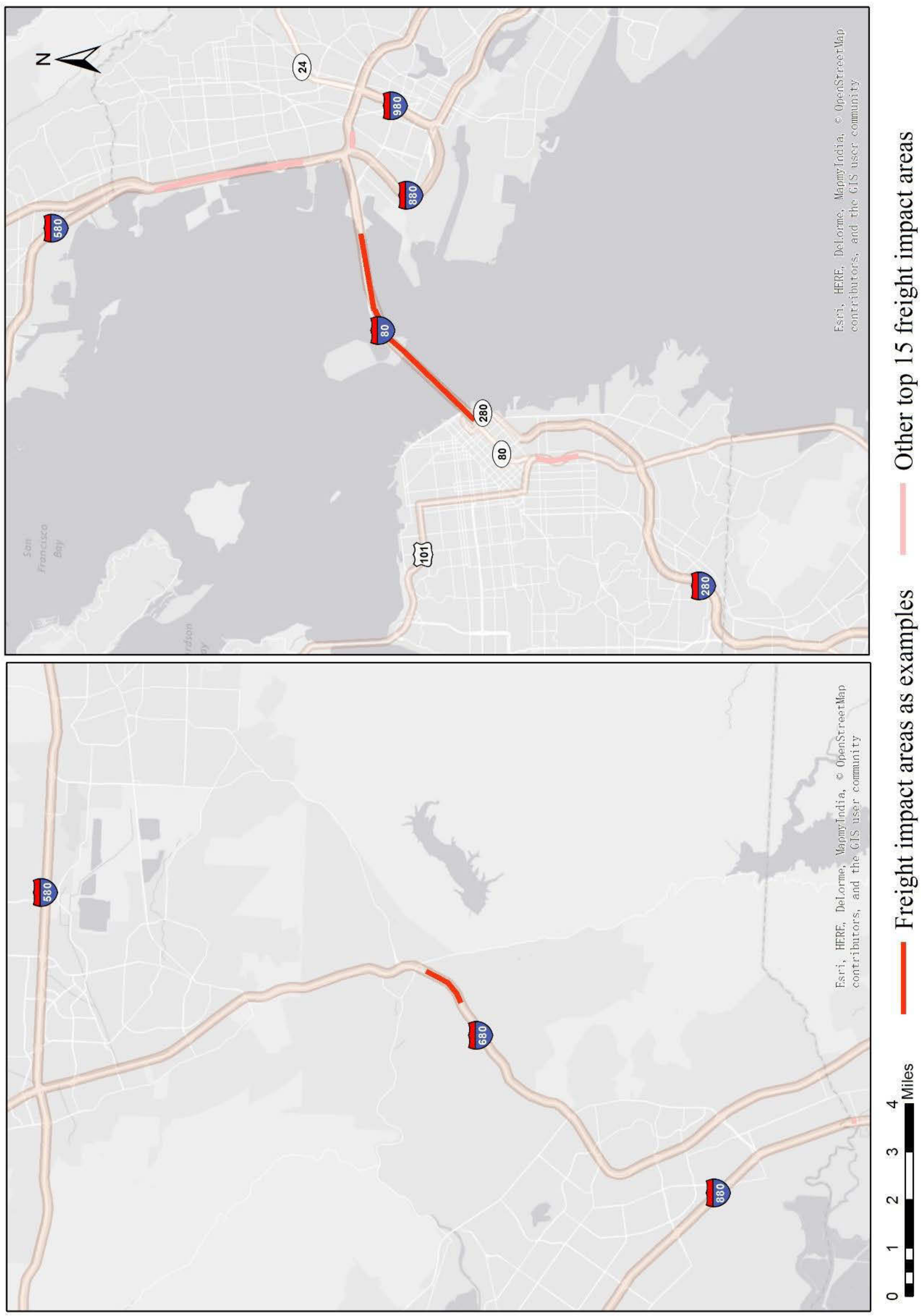

Figure 2.4-4 Map of two impact areas in the San Francisco region, I-680 Fremont (left) and I-80 San Francisco Bay Bridge (right)

2.4.1.3. Rest of California

In the rest of California, we identify the top 15 freight impact areas on the National Highway System using the PeMS database. The definition of highway freight impact area here is similar to that in the two regions above, but the way we operationalize the definition depends on the structure of the PeMS data.

PeMS provides real-time and historical performance data and analysis reports on congestion bottlenecks across the entire state of California. The PeMS data is obtained primarily from Intelligent Transportation System (ITS) Vehicle Detector Stations (VDSs), Traffic Census Stations and Weigh-In-Motion (WIM) Sensors, all of which are point locations. Without link-based data, PeMS does not allow the same analysis on freight bottlenecks as in the Los Angeles and the San Francisco regions. Therefore, we start with the Vehicle Detector Stations that experience the most severe traffic congestion delay through the "Performance-Bottlenecks-Top Bottlenecks" report produced by PeMS. Note that the "Top Bottlenecks" defined in PeMS are VDS point locations. We observe PM peak hours (4-6 pm) on all weekdays in the most recent month (in the analysis, 3/10/2017-4/10/2017), and obtain a list of VDSs with the highest average congestion delay and at least 20 active days of data for each Caltrans district (except for District 4-Bay Area, District 7-LA/Ventura and District 8-San Bernardino/Riverside).

We then compile all selected VDSs, from which we pick the top 15 (in terms of average congestion delay) as candidates for further analysis. In the next step, we go back to PeMS to locate the closest neighbor station of each of those top 15 VDSs in each direction, and calculate the PHFCV of all 45 stations (top 15 + two neighbors for each of them). For each top VDS, we keep only one neighbor with higher PHFCV (than the other neighbor station) and regard the road segment between each top VDS and its remaining neighbor station as a top "freight impact bottleneck." Finally, we calculate the APHFCV as the average value of PHFCV of two stations on a "freight impact area." The calculations used to produce the "freight impact areas" in the rest of CA are as follows (see the Figure 2.4-5). Similarly, Total Peak Hour Freight Congestion Delay (TPHFCD) can be calculated following the steps shown in Figure 2.4-6. The Average Peak Hour All-vehicle Congestion Value (APHACV) and Total Peak Hour All-vehicle Congestion Delay (TPHACD) are calculated the same way, using total vehicle volume rather than truck volume and private vehicle free flow speed.

For peak hours (4-6 pm), calculate the PHFCV of each top 15 Vehicle Detection Station (Station 1) and its two neighbor stations (Station 2 and 3). If the PHFCV of the Station 2 is larger than that of the Station 3, the road segment between the Station 1 and the Station 2 is identified as a top "freight impact area".

The Average Peak Hour Freight Congestion Value = average value of PHFCV of the Station 1 and PHFCV of the Station 2.

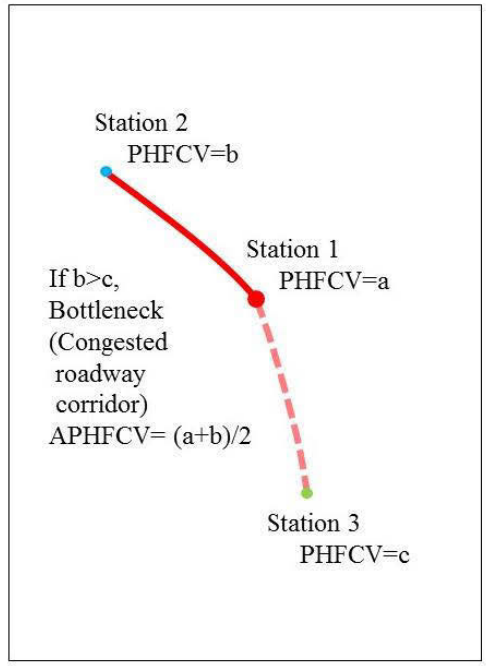

Figure 2.4-5 Steps of calculating average peak hour freight congestion value in the rest of California (using the PeMS data)

For peak hours (4-6 pm), calculate the PHFCD of each top 15 Vehicle Detection Station (Station 1) and its two neighbor stations (Station 2 and 3). If the PHFCD of the Station 2 is larger than that of the Station 3, the road segment between the Station 1 and the Station 2 is identified as a top "freight impact area".

The Total Peak Hour Freight Congestion Delay = sum of PHFCD of the Station 1 and PHFCV of the Station 2.

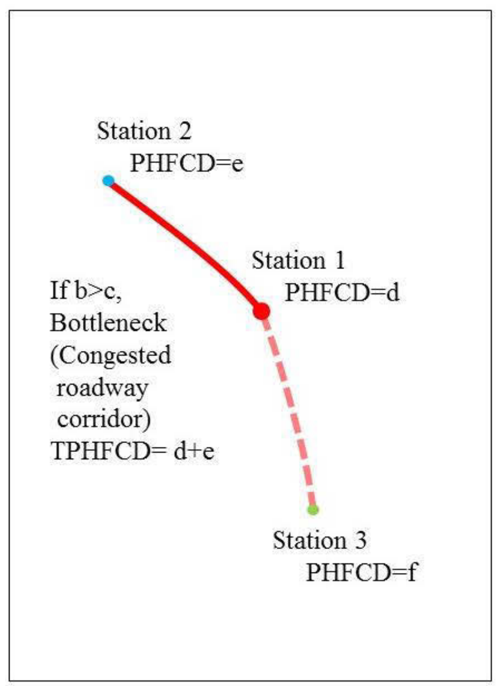

Figure 2.4-6 Steps of calculating total peak hour freight congestion delay in the rest of California (using the PeMS data)

The top 15 freight impact areas are listed and mapped in Figure 2.4-7. Table 2.4-5 shows the descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the rest of California. It bears noting that 11 of the 15 are located in the Sacramento (6) and San Diego (5) regions, the third and fourth largest metro areas in California respectively. Both are regional freight hubs, Sacramento for the north San Joaquin Valley, and San Diego for cross border trade. The remaining four are located in the San Joaquin Valley: three on SR 99 from Modesto north to Manteca, and the last just north of Fresno. These results are expected, given the volume of agricultural activity in the Valley. It can be seen that the scale of these impact areas is much smaller than those in Los Angeles or San Francisco. This is largely because we defined the impact areas as a single segment, rather than allowing for multiple segments.

The average share of trucks for the top 15 freight impact areas in the rest of California is lower than that in Los Angeles, but a slight bit higher than that in San Francisco. It indicates that in the rest of the state, on certain segments of highways like I-5 and SR 99, the freight movement is also very significant. Finally, there is less overall traffic and higher peak speeds outside of the two largest metro areas. The total peak hour delay is thus much smaller than that in Los Angeles and San Francisco, given the lower traffic volumes, less severe congestion, and shorter length of the impact areas. Details on all the freight impact areas are available in Appendix A, Table 3.

Table 2.4-5 Descriptive statistics of key variables of the top 15 freight impact areas on the National Highway System in the rest of California

	Average	Minimum	Maximum
Length (mile)	0.78	0.08	4.35
Average total volume per direction during PM peak	4,476	1,243	6,042
Average truck volume per direction during PM peak	198	66	427
Average share of trucks	5.28%	1.37%	12.21%
Congestion speed (mile/hour)	36.62	23.40	53.72
Average peak hour all-vehicle congestion value (vehicle*mile/hour)	88,289	7,620	181,639
Total peak hour all-vehicle delay (vehicle*hour)	27.2	1.1	88.1
Average peak hour freight congestion value (truck*mile/hour)	3,183	605	5,328
Total peak hour freight delay (truck*hour)	1.0	0.1	3.3

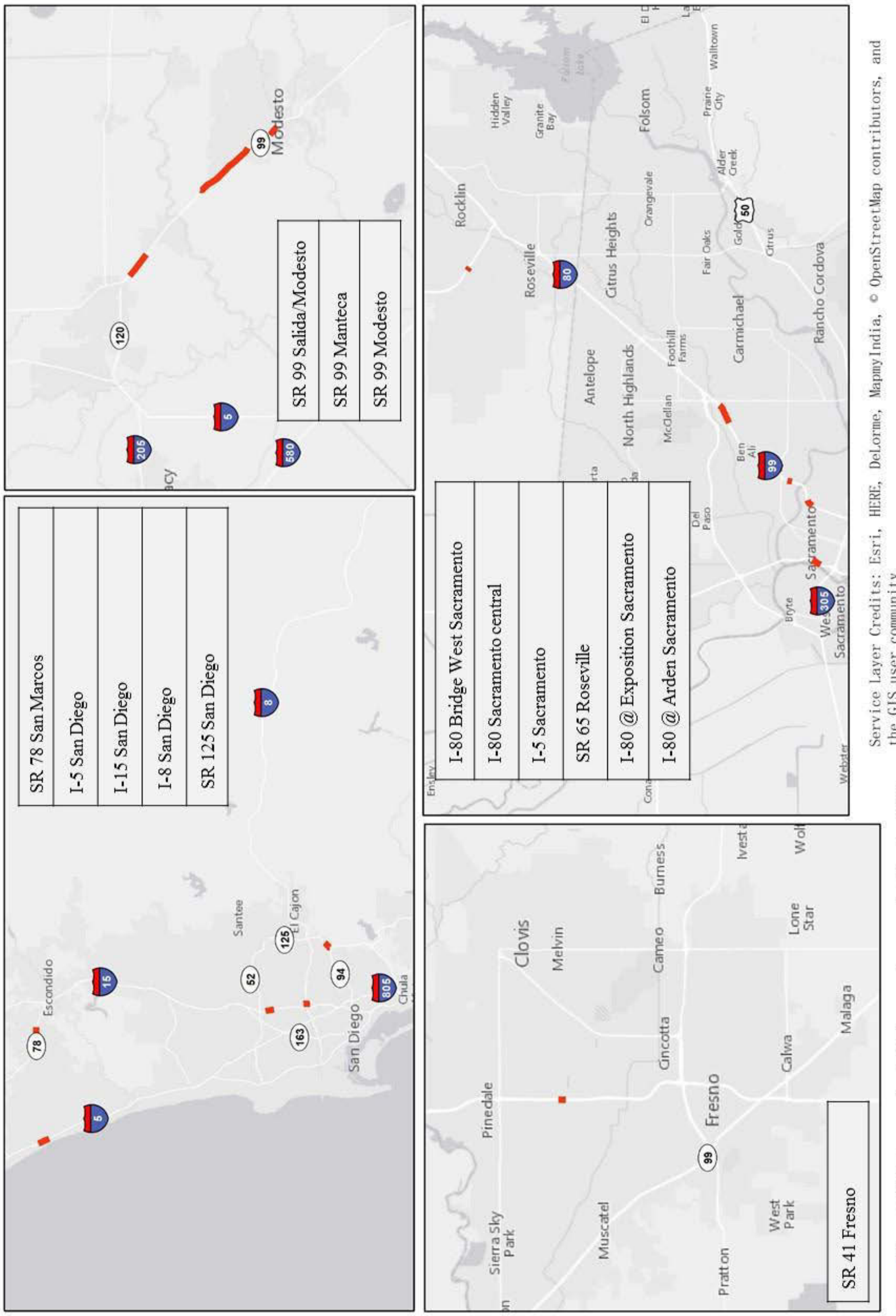

Figure 2.4-7 Top 15 freight impact areas on the National Highway System during PM peak hours in the rest of California

2.4.2. Major arterial freight impact areas

We used the same process to identify the top 15 freight impact areas in the Los Angeles and San Francisco regions. We are not able to examine arterials for the rest of California due to lack of data.[6] As with our results on highways, arterial freight impact areas are not necessarily consistent with the locations of conventionally defined freight bottlenecks. In Los Angeles, arterial freight impact areas are found at many suburban locations, as well as areas close to Los Angeles International Airport and the Ports of Los Angeles and Long Beach (see Figure 2.4-8). In San Francisco, impact areas are scattered; some in the urban core and some along major regional highway links (See Figure 2.4-9). The impact areas are listed in Table 2.4-6. Table 2.4-7 and 2.4-8 show the descriptive statistics of key variables of the top 15 freight impact areas on the arterial system in the Los Angeles and San Francisco regions respectively. The impact areas are very short in length (well under 0.5 mile, and several less than 0.1 mile) and likely related in most cases to specific intersections or traffic signal problems. We can see that compared to highway freight impact areas, arterial freight impact areas have lower traffic volumes, shares of trucks, and congestion speed (of course, on arterials), and therefore less significant delays. But considering the limited road space and more complicated activities on local arterial roads, the freight impacts are still of particular importance. Meanwhile, arterial freight impact areas in Los Angeles have greater spatial extent, but much lower shares of trucks than those in San Francisco. The high shares of trucks in San Francisco might partly result from the road networks constrained by the unique topography in the region. Details on each impact area are available in Appendix A, Table 4 and Table 5.

[6] If the data were available, it would be possible to identify arterial freight impact areas in other areas. As noted earlier, however, currently there is no data source available. It would also be possible to use our method for any metro areas for which an equilibrium network assignment by vehicle class had been performed.

Table 2.4-6 Top 15 arterial freight impact areas, Los Angeles and San Francisco regions

Los Angeles	San Francisco
Ave W @ State Highway 138 (Los Angeles County)	Stony Point Rd @ Hearn Ave (Santa Rosa)
Glendale Blvd @ N Alvarado St (Los Angeles)	Farmers Ln @ SR-12 (Santa Rosa)
Ventura Blvd @ I-405 (Los Angeles)	Sunol Blvd @ I-580 (Pleasanton)
Van Buren Blvd @ Jurupa Ave (Riverside)	Morello Ave @ Rolling Hill Way (Martinez)
State Highway 138 (San Bernardino County)	Bay Farm Island Bridge (Alameda)
Valley Blvd @ I-605 (El Monte)	Shattuck Ave @ Dwight Way (Berkeley)
S LA Cienega Blvd @ Fairview Blvd (Los Angeles)	Ygnacio Valley Rd @ I-580 (San Francisco)
Garfield Ave @ I-5 (Commerce)	4th Street @ Folsom St (San Francisco)
W 6th St @ SR-91 (Corona)	Hegenberger Rd @ Edgewater Dr (Oakland)
E Anaheim St @ Alameda St (Los Angeles)	Masonic Ave @ Felt St (San Francisco)
Slauson Ave @ I-605 (West Whittier-Los Nietos)	Market St @ 3rd St (San Francisco)
W Willow St @ Fashion Ave (Los Angeles)	N 1st St @ W Rosemary St (San Jose)
W Sunset Blvd @ N Beaudry Ave (Los Angeles)	Fremont St @ Harrison St (San Francisco)
S Sepulveda Blvd @ W Century Blvd (Los Angeles)	W Santa Clara St @ Notre Dame Ave (San Jose)
E Florence Ave @ Eastern Ave (Bell Gardens)	Mission Street @ New Montgomery St (San Francisco)

Table 2.4-7 Descriptive statistics of key variables of the top 15 freight impact areas on the arterial system in the Los Angeles region

	Average	Minimum	Maximum
Length (mile)	0.56	0.04	3.43
Average total volume per direction during PM peak	10,701	3,406	19,503
Average truck volume per direction during PM peak	428	259	750
Average share of trucks	4.67%	2.07%	6.44%
Congestion speed (mile/hour)	8.41	4.49	16.90
Average peak hour all-vehicle congestion value (vehicle*mile/hour)	302,566	171,754	549,094
Total peak hour all-vehicle delay (vehicle*hour)	498.7	54.3	1,735.9
Average peak hour freight congestion value (truck*mile/hour)	12,267	9,194	17,711
Total peak hour freight delay (truck*hour)	25.5	2.1	108.0

Table 2.4-8 Descriptive statistics of key variables of the top 15 freight impact areas on the arterial system in the San Francisco region

	Average	Minimum	Maximum
Length (mile)	0.22	0.06	0.65
Average total volume per direction during PM peak	7,544	1,557	11,822
Average truck volume per direction during PM peak	849	224	2,228
Average share of trucks	10.49%	4.77%	24.38%
Congestion speed (mile/hour)	13.64	6.02	20.70
Average peak hour all-vehicle congestion value (vehicle*mile/hour)	101,729	45,889	151,143
Total peak hour all-vehicle delay (vehicle*hour)	65.7	7.8	304.3
Average peak hour freight congestion value (truck*mile/hour)	9,638	7,008	11,177
Total peak hour freight delay (truck*hour)	5.5	1.4	14.5

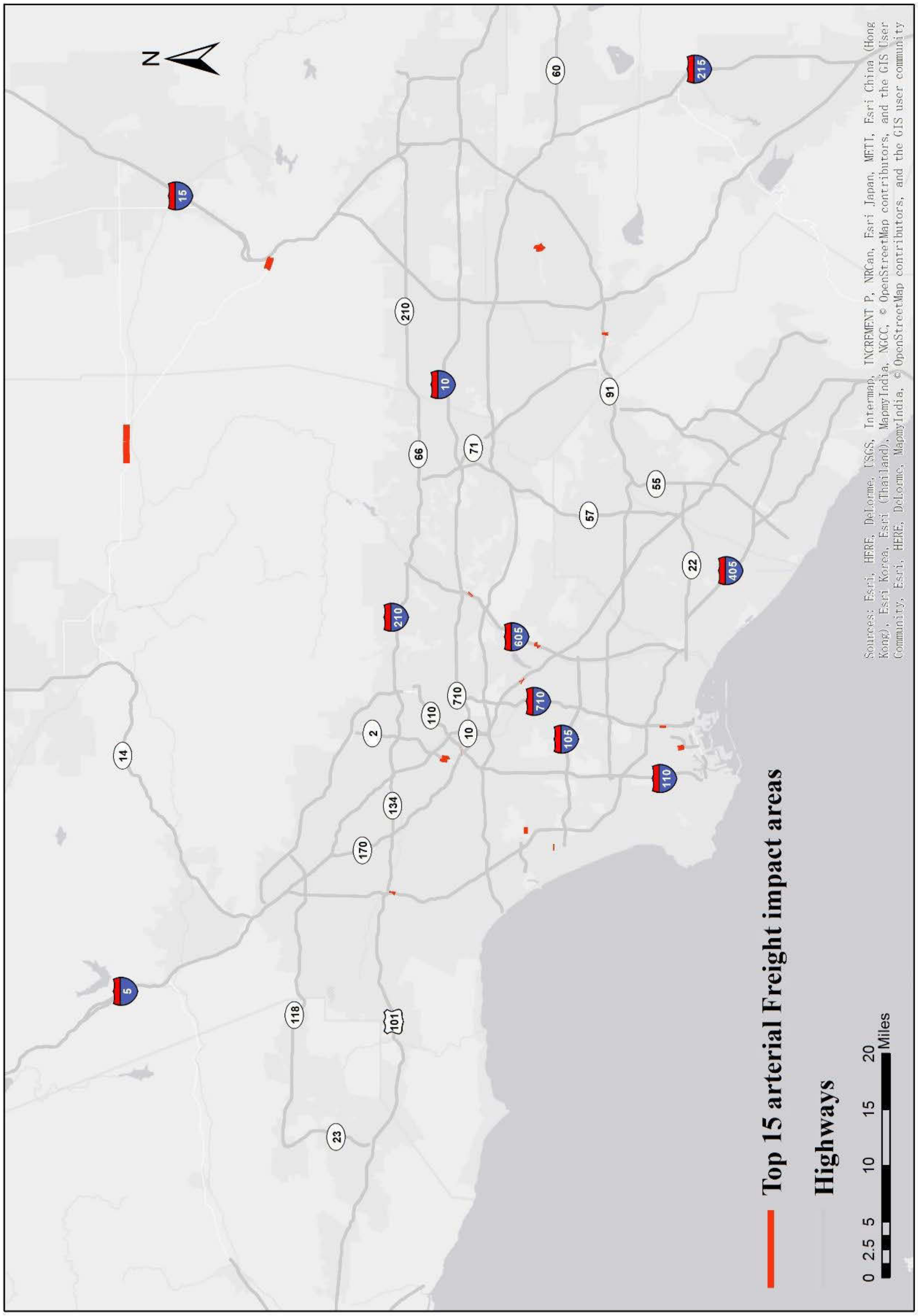

Figure 2.4-8 Top 15 arterial freight impact areas during PM peak hours in the Los Angeles region

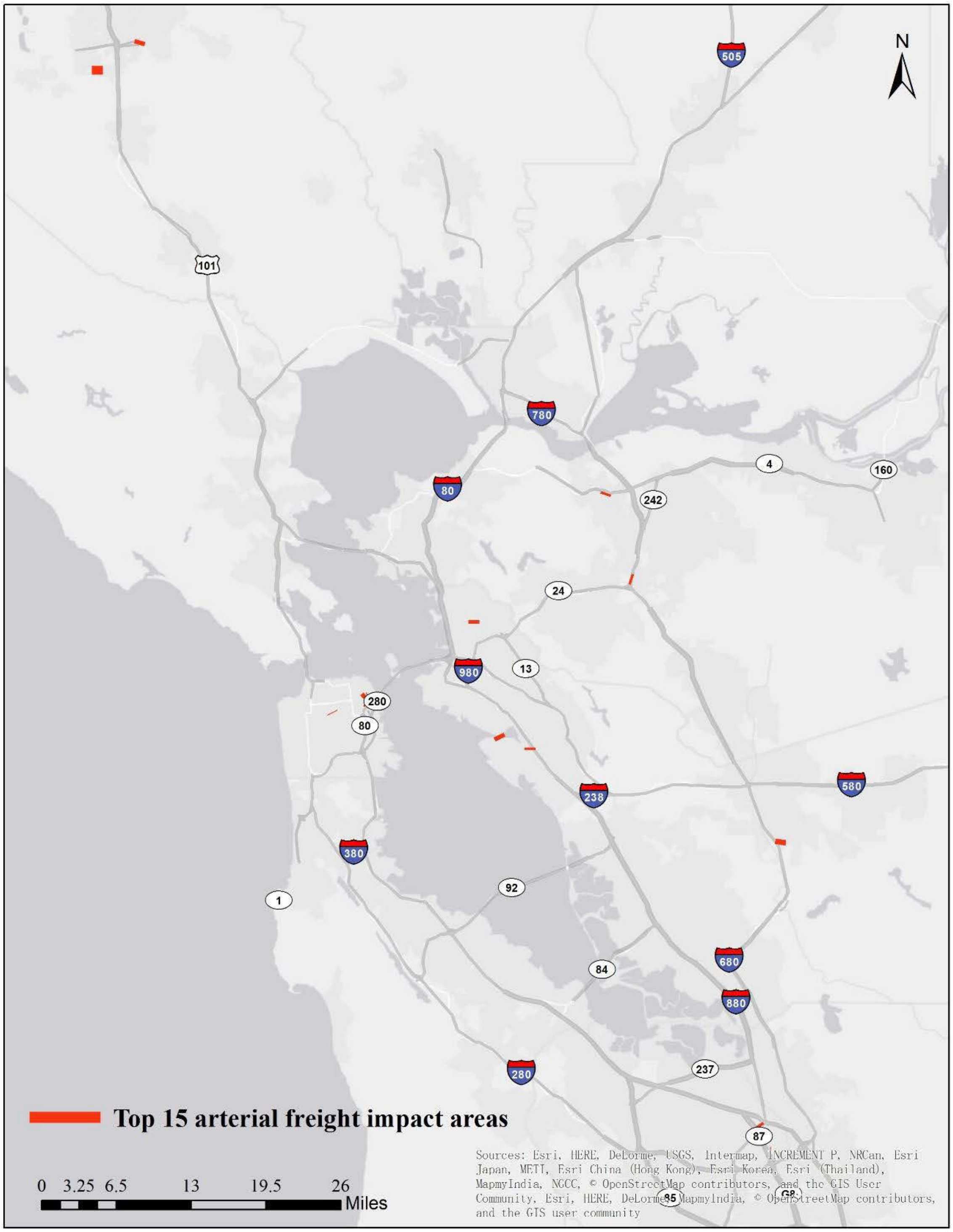

Figure 2.4-9 Top 15 arterial freight impact areas during PM peak hours in the San Francisco region

2.5. Impacts of rail crossings on arterials

Freight trains compete with vehicular traffic at at-grade rail crossings. In areas with high volumes of truck movement, arterial truck traffic is regularly impacted by the closure of rail crossings. We scan the 100 arterials with the highest peak hour all-vehicle congestion delays and analyze their spatial relationship with at-grade freight rail crossings. A total of nine arterial segments in the Los Angeles region are found potentially affected by adjacent rail crossings (see Figure 2.5-1). Four of them are located near the Port of LA/LB complex, three of them are located near the BNSF-LA Hobart and UP East LA intermodal terminals, and another two are near the I-605/I-405 interchange. Note that our method looks only at the most congested arterials, so we can conclude only that for these arterials, rail crossings do not appear to be a serious problem. It is quite possible that rail crossings impose delays on less congested arterials. In order to fully examine rail crossing impacts, we would need both traffic volume and rail schedule data. Such an analysis is beyond the scope of this project.

We use a similar approach to identify arterial segments potentially affected by adjacent rail crossings in the San Francisco region, and five segments are filtered out (see the Figure 2.5-2). None of them are in close vicinity of major ports and intermodal terminals. The difference may be due to the much smaller volume of rail freight traffic in the San Francisco region (please see 2018 California State Rail Plan).

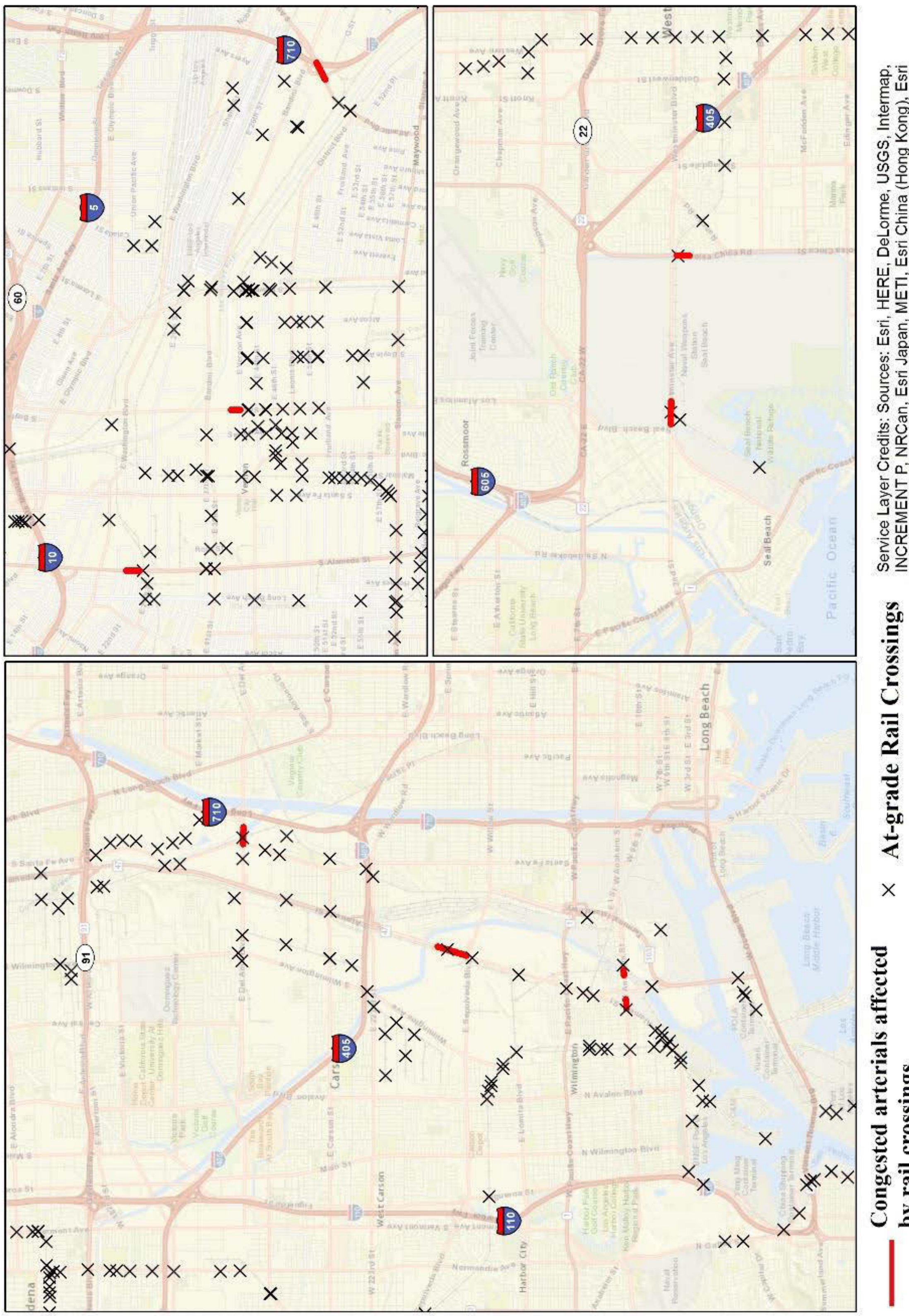

Figure 2.5-1 Location of congested arterial segments in the Los Angeles region potentially affected by adjacent rail crossings

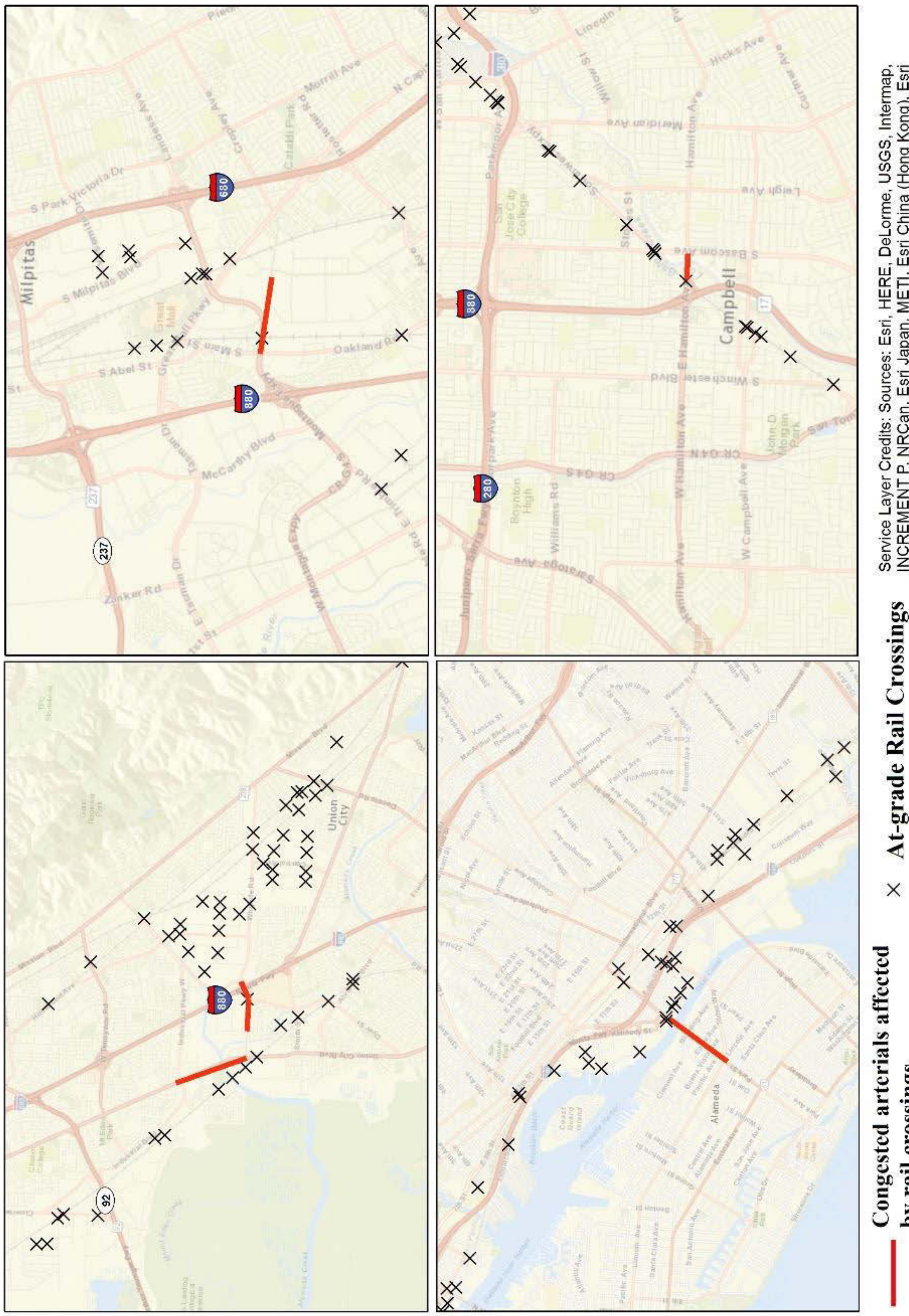

Figure 2.5-2 Location of congested arterial segments in the San Francisco region potentially affected by adjacent rail crossings

2.6. Impacts of freight rail on passenger rail

This section considers another aspect of freight impacts, the effects of freight rail on passenger rail. We draw from the 2013 California State Rail Plan (CSRP) and the newly released 2018 CSRP. Based on an inventory of current rail system assets, the 2013 CSRP analyzes long-range passenger travel demand and domestic and international freight demand using 2020 as the five-year horizon, 2025 as the 10-year horizon, and 2040 as the 20-year horizon. The 2018 CSRP sets three temporal plans: 2022 short-term plan, 2027 mid-term plan and 2040 long-term plan. After comparing the development backgrounds, characteristics, challenges and improvement plans of passenger rail systems with freight rail systems, the CSRP shifts the focus to the integration and conflict between these two, which is relevant to our discussion of freight impacts.

The CSRP anticipates that passenger rail patronage and service will increase over the planning time horizon. It is projected that increased freight traffic growth (2.5% annually) driven by rapid development of freight-related industry outputs will outpace that of population (1.1%) and employment (1.0%) in the next three decades, thus, generating demand for a robust goods movement infrastructure. With increases in both passenger and freight demand, the potential for conflicts also increases.

The major conflict between freight and passenger rail is in shared-use corridors. Traffic characteristics such as train type mix and train performance, as well as directional peaking affect the usable capacity of a particular line. An increase in the number of trains on a shared-track corridor may constrain train scheduling, causing increased train delays. This can be worse during peak times when freight and passenger train volumes are at their maximum. Since commuter trains generally run more frequently during morning and evening commute times while freight trains spread more evenly throughout the day, peak-period commuter trains have greater potential to create rail system congestion under shared-track usage.

Section 7.2 in the 2013 CSRP identifies freight and passenger train volume forecasts on shared-track corridors. Based on the classification of forecasted train volumes shown in Figure 2.6-1 and 2.6-2, the report gives a general description of key demand-related issues in shared-track rail corridors regarding capital investment, operation coordination and infrastructure limitations and improvements focusing on areas of the San Joaquin Valley, San Francisco Bay Area, and Southern California. Possible freight rail effects on shared-track corridor performance are mainly congestion and delay, due to increasing freight rail demand and the difficulty of effectively integrating freight and passenger rail operations. Problems exist both in Northern California (the San Jose to Oakland corridor used by the Capitol Corridor service) and in Southern California (the UP Alhambra subdivision between Los Angeles and Colton, and the

BNSF line between Hobart and Fullerton). Both are connected to freight rail access to the state's busy ports in Oakland, Los Angeles, and Long Beach.

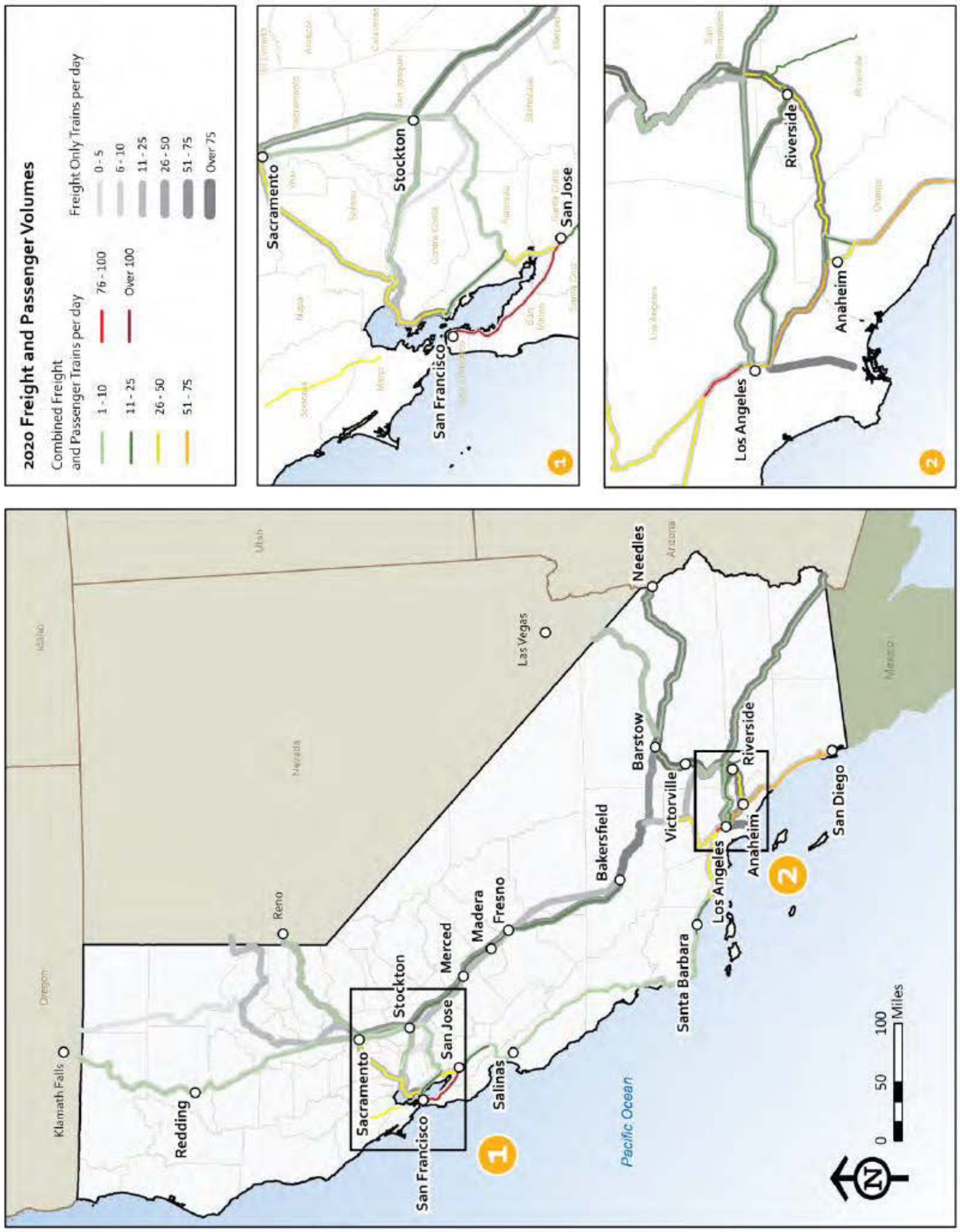

Figure 2.6-1 Projected 2020 Daily Train Volumes on California's Shared-Track Rail Corridors (Source: 2013 California State Rail Plan)

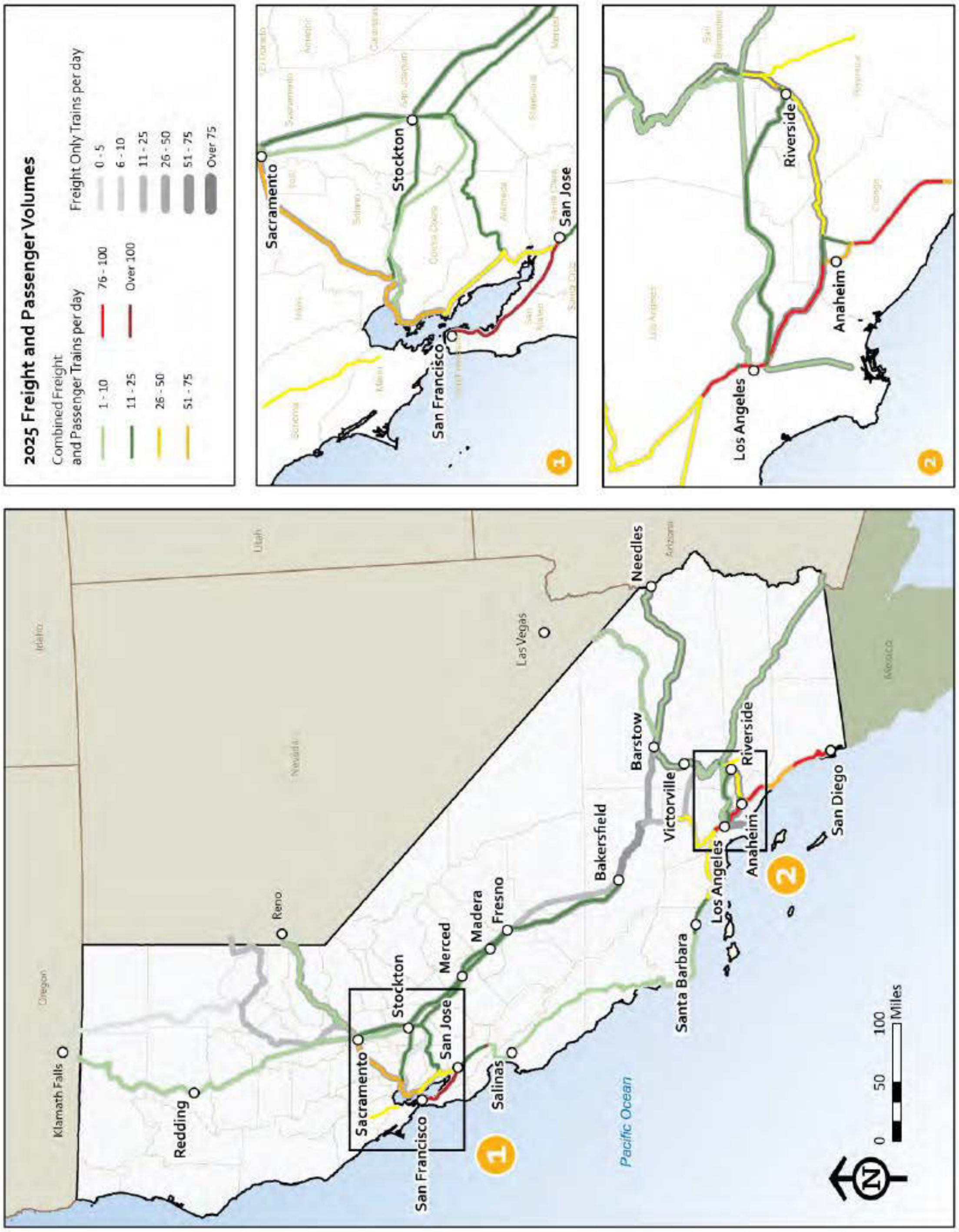

Figure 2.6-2 Projected 2025 Daily Train Volumes on California's Shared-Track Rail Corridors (Source: 2013 California State Rail Plan)

Section 5 in the 2018 CSRP discusses the rail investment strategy and identifies six major areas of need and opportunity for freight rail in California: 1) Trade corridor improvements, 2) Economic development and short lines, 3) Grade-crossing improvement needs throughout the state, 4) Additional terminal and yard capacity, 5) Short-haul rail improvements, and 6) Advancement of zero and near-zero emissions technologies. Project examples are listed associated with every strategy to evaluate the project impacts, such as the City of Colfax grade separation project. Congestion and delay problems are projected to be improved by multiple strategies, especially through grade-crossing improvement projects and terminal and yard capacity projects.

2.7. Linking freight impact areas to other freight modes

The final step in our analysis is to link freight impact areas to freight activities: Is there a relationship between the location of freight impact areas and freight-related facilities or activities? If freight impacts are related to specific freight activities it may be possible to mitigate impacts by managing freight more efficiently at freight activity locations. Due to time and resource limitations, we offer a descriptive discussion of possible relationships. Systematic analysis is beyond the scope of this project.

We mapped the major airports, ports, and rail intermodal terminals over the highway freight impact areas. We used the top 12 airports by cargo volume from the CFMP; 5 are located in Los Angeles, and 3 are located in San Francisco. The major ports are Los Angeles, Long Beach, Oakland, and Richmond. We use the major intermodal terminals as defined in the 2013 California State Rail Plan (AECOM et al. 2013); 6 are located in Los Angeles, and 2 are located in San Francisco. Details on airports, ports and rail intermodal terminals in relation to highway and arterial freight impact areas are available in Appendix A, Table 6 to Table 11.

Examples for airports are shown in Figure 2.7-1 and Figure 2.7-2 below. Figure 2.7-1 shows the Ontario International Airport (ONT) and Los Angeles International Airport (LAX) in the Los Angeles region and Figure 2.7-2 shows the Oakland International Airport (OAK) and San Francisco International Airport (SFO) in the San Francisco region. All of these airports serve both passenger and cargo transport. However, the relative shares of air cargo shipments to passenger trips in ONT and OAK are significantly higher than LAX and SFO, even though cargo volumes are much greater at LAX and SFO. These differences in airport services are consistent with the spatial distribution of freight impacts. For LAX and SFO, the high volume of passengers washes out the impact of cargo; the opposite is true for ONT and OAK. For instance, the I-405 in the vicinity of LAX is severely congested during peak hours, but it consists mostly of passenger vehicles. The freight impacts on the I-405 are therefore less significant than what we find on the SR-60 near ONT; see Figures 2.7-1 and 2.7-2.

Examples for intermodal terminals are shown in Figure 2.7-3 below, which includes the BNSF LA-Hobart in the Los Angeles region and the UP Railport in the San Francisco region. As intermodal terminals receive and generate high volumes of truck trips, the freight impacts on the nearby highways and arterials are very heavy, especially highways connecting major ports. For instance, the BNSF LA-Hobart terminal processes a high volume of freight from the Los Angeles-Long Beach port complex, and the I-710 connecting them is greatly affected by freight movement during the peak hours.

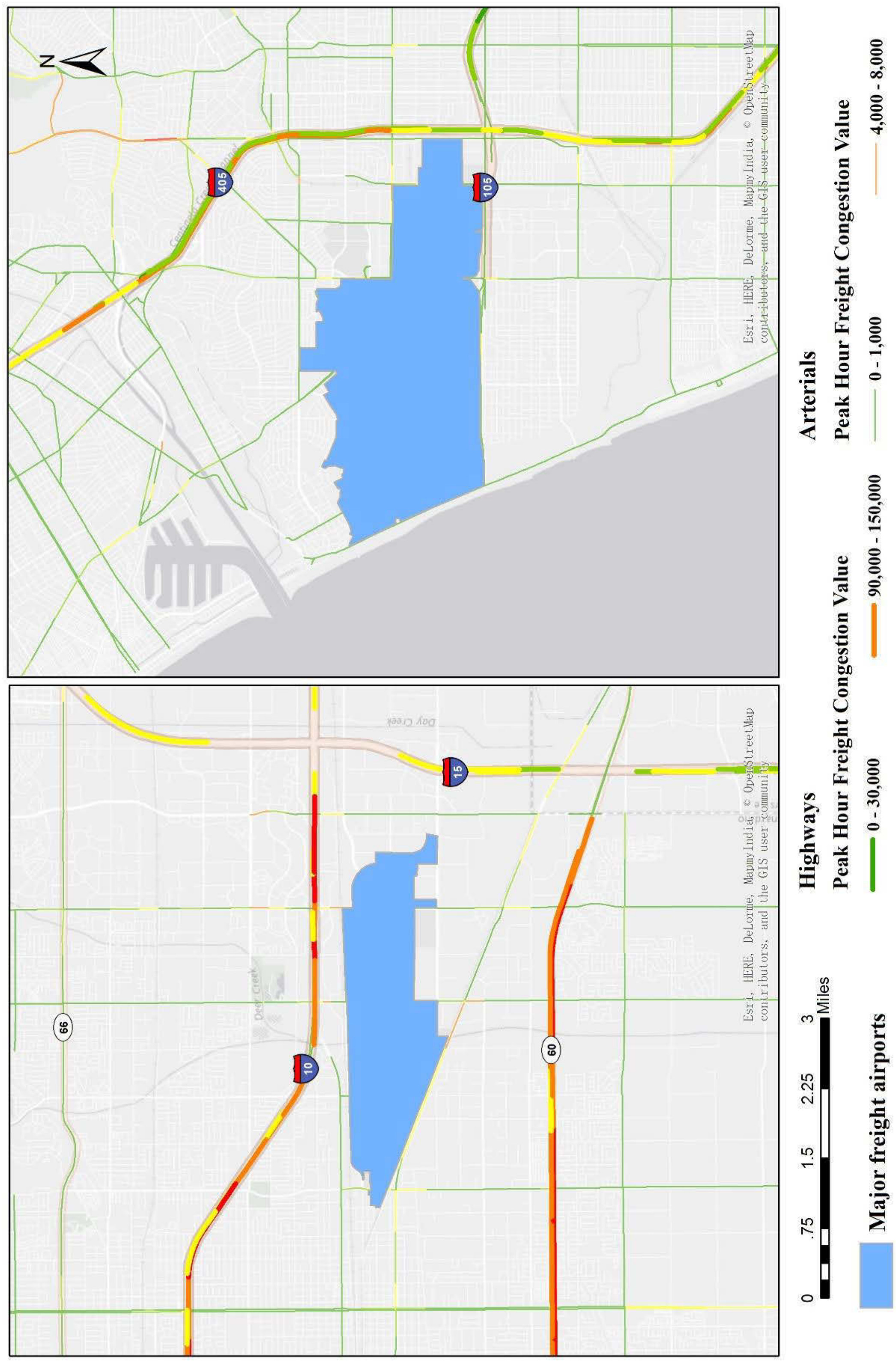

Figure 2.7-1 Map of two airports, Ontario International Airport (left) and Los Angeles International Airport (right), in relation to highways and arterials

Figure 2.7-2 Map of two airports, Oakland International Airport (left) and San Francisco International Airport (right), in relation to highways and arterials

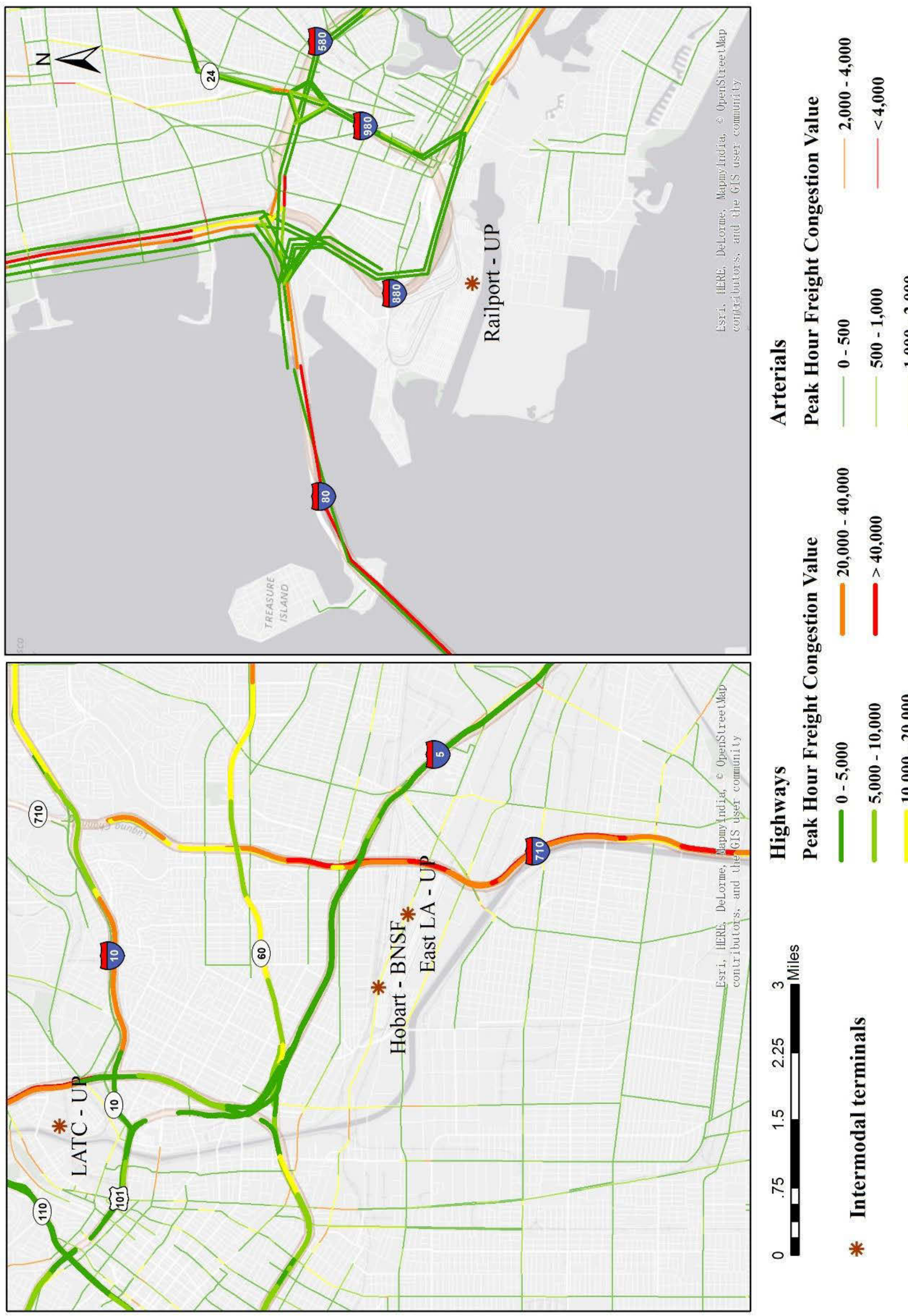

Figure 2.7-3 Map of two intermodal terminals, BNSF LA-Hobart (left) and UP Railport (right), in relation to highways and arterials

2.8. Conclusion

Steady population and economic growth in California have been driving the substantial increase in goods movement. In spite of the state's efforts, congestion continues to increase. High volumes of freight movement is one of many factors contributing to increased congestion. Freight and passenger vehicles compete for space, but they may not equally contribute to congestion. Trucks, especially combination trucks, disproportionately contribute to traffic congestion, due to slower acceleration and deceleration rates and more limited maneuverability. On the National Highway System and the major arterials, traffic speed is significantly affected by the flow of trucks. On the other hand, the distribution of truck volumes on the road system largely depends on the freight demand in surrounding areas. The highways and arterials close to major freight generators including airports, seaports, and intermodal terminals generally have higher proportions of trucks and limited traffic speed.

We reviewed the existing studies on identification of freight impact bottlenecks, and developed a new methodology to define freight impact areas. By applying the methodology to Los Angeles and San Francisco, we identify the top 15 highway freight impact areas and top 15 arterial freight impact areas for each region. Another 15 top highway freight impact areas in the rest of California (outside of LA and SF) are also identified using PeMS data. We calculate total delay in these areas as a proxy for freight impact. Furthermore, we relate these freight impact areas to major freight generators including airports, seaports, and intermodal terminals, and find that many of the identified freight impact bottlenecks are in fact close to freight generators.

The concept of freight impact areas provides a new tool for freight impact analysis and will assist California in complying with the FAST Act freight planning requirements.

Chapter 3: Review of Existing California Freight Mobility Plan

3.1. Introduction

Task 2 of this project is a review of the 2014 California Freight Mobility Plan (CFMP). The intent of reviewing the CMFP was to use as much existing information as possible, given the short time frame of the research. The plan review was to serve three purposes: 1) compare the previous forecast of major freight congestion and delay issues with the current 2040 forecast, 2) use the CFMP's mitigation measures as the baseline for our recommendations, and 3) analyze the effectiveness of implemented strategies.

Our initial data gathering revealed that there is no 2040 forecast available from the state, nor is there a formal forecast of statewide truck and traffic demand in the CFMP. Furthermore, the CFMP is not a traditional transportation plan. There is no future forecast of system-wide demand, no "no-build" or "build" scenarios, and no set of projects and policies to mitigate congestion or other problems revealed by the forecast. Rather, it is more a description of the state of the system and the projects being pursued throughout California. It also provides general guidance on the types of strategies and goals the state should pursue.

Given the contents of the CFMP, we will 1) present an overview of the contents in the CFMP, with the focus on funding priorities and conditions and performance, 2) summarize the recommended strategies in the CFMP as the baseline for possible mitigation strategies, and 3) make recommendations on data for updating the CFMP.

3.2. Contents of the CFMP

The CFMP gives a comprehensive overview of the California freight transportation system regarding physical assets, operation and management, and context of issues on social and community outreach, technology applications and other key aspects. The first three sections of the plan provide a general framework to identify problems and propose strategies, supported by specific regional and mode analyses in the appendices.

Under the vision framed by the six state goals -- 1) economic competitiveness, 2) safety and security, 3) freight system infrastructure preservation, 4) environmental stewardship, 5) congestion relief, and 6) innovative technology and practices -- the CFMP proposed six general strategies to address the needs of California's full, multi-modal integrated freight system. The strategies are: 1) maintain and enhance existing assets, 2) apply new technologies and system operations practices, 3) address negative impacts of freight movement, 4) strategically add new capacity, 5) strengthen the collaborative approach, and 6) create dedicated, reliable, long-term freight funding programs. Strategies are further discussed in the section below: Recommended Strategies in the CFMP.

Four project types in five geographic contexts are to be used to target funding for specific program goals. The four project types are: 1) system preservation, 2) operations and management, 3) community and environmental stewardship, and 4) capacity expansion. And the geographic contexts are: 1) gateways, 2) corridors, 3) last mile connectors, 4) hubs, and 5) broad initiatives. A comprehensive analysis of strengths and needs of California Freight Networks has been conducted consistent with the USDOT's guidance for freight decisions, such as allocating substantial, dedicated freight funding at the national, state, and regional levels. The CFMP concludes that acquiring funds from new sources and increasing levels of freight funding from current sources are the biggest challenges for improving the state freight system. A recommended strategy is to prioritize the funding for multi-goal programs, meaning programs that meet more than one of the state goals.

3.2.1. Funding Priorities

In response to USDOT guidance on state freight plans, the CFMP structures policies and implementation approaches consistent with MAP-21 and the California Sustainable Freight Strategy (2014) launched by the California Air Resources Board (CARB). The CFMP encourages multi-state and multi-agency collaboration with Metropolitan Planning Organizations (MPOs) and Regional Transportation Planning Agencies (RTPAs), and public private partnerships under the leadership of Caltrans and the California State Transportation Agency (CalSTA).

A list of 707 projects in Appendix A offers specific information on project type, CFMP goals, project status, and other metrics. The progress of these projects ranges from "not fully funded" to "under construction." There is no information about the starting or completion dates of the projects, and the absence of project implementation status makes it impossible to track the effectiveness of related strategies. Out of the projects, 48% (340) focus on capacity expansion, 36% (255) on operations and management, 9% (64) on preservation, and 3% (22) on community and environment.

3.2.2. System Performance and Problems

The CFMP conducts a general assessment of the conditions and performance of the California freight system (highways, rails, seaports and airports) using three categorized metrics: freight infrastructure, congestion, and safety. It identifies main freight routes, freight issues including regional heavy truck traffic (focusing on the SCAG and San Diego regions), and problems of multimodal congestion and delays in each county. Summaries of regional congestion areas are supported by maps of main bottlenecks.

However, freight problems are not systematically discussed in any section. There is no state level conclusion regarding the core problems on each mode, for example, statewide truck corridor congestion. Forecasts for 2025 and 2040, using the base year 2012, are provided only for state population growth, mode shipments and commodity trade, and emissions. There is a forecast of the general increase in shipments, but not their geographic or network distributions.

Although there is very limited discussion on freight problems featuring regional truck traffic congestion and delay, more local infrastructure, operational and policy issues are listed in some chapters of the appendix. Following the profiles of each port (seaport, airport, border port of entry, political region and Caltrans district), major issues are briefly presented, which can be categorized into the following types: environmental impacts (air quality, noise, public health etc.), insufficient funding, limited parking, limited capacity and intermodal connections, facility maintenance, and location disadvantage. Related projects specific for the port were also presented. However, information of starting or ending time is not available for all the projects. The number of projects with implementation status information is very limited, and there is no direct connection of projects to strategies. With extensive research on individual projects, it would be possible to evaluate the impacts of some projects listed in the appendix but such assessment is still inadequate for a full evaluation of the strategies organized in Table 1, Chapter 1.1.

Under USDOT guidance on state freight plans, the CFMP provides a general description of California's economic background, social concerns of Native American Tribes, development of the freight labor market, community and environmental context focusing on the 2050 goal of near-zero emissions, security resilience, technology applications and significant borders.

The CFMP relies heavily on secondary sources. Many conclusions are not from direct analysis of data, but from regional data and consultant reports. For instance, examples of areas of truck congestion and delay come from the 2013 San Joaquin Valley Interregional Goods Movement Plan and the 2014 San Francisco Bay Area Freight Mobility Study by Cambridge Systematics. The least reliable (those having the greatest potential for delay) Corridor Mobility Improvement Account (CMIA) corridors were analyzed in the Caltrans Mobility Performance Report 2010 (updated July 2013). Data on warehousing and distribution facilities come from the 2013 SCAG Regional Goods Movement Plan.

3.3. Recommended Strategies in the CFMP

The six broad strategies summarized below have been identified to address the CFMP vision and goals.

1) Maintaining and enhancing existing assets;
2) Applying new technologies and system operations practices to improve the performance of all aspects of the freight system;
3) Addressing the negative impacts of freight movement as a component of each freight project and through programs and projects specifically targeted to address impacts on a broad scale;
4) Strategically adding new capacity;
5) Strengthening collaboration among State and regional agencies, advisory groups, the freight industry, communities, and advocacy groups;
6) Creating dedicated, reliable, long-term freight funding programs.

Categorized by objectives under the six goals, the strategies give general guidance mainly on infrastructure and operation improvement, rather than on policies. For each strategy, the discussion includes the following steps: 1) identify the problem, 2) present analysis; 3) identify infrastructure and/or operational improvements; 4) identify funding sources; 5) establish criteria/standards; 6) prioritize programs, and 7) build institutional capacity for implementation.

Strategies targeting infrastructure improvements include eliminating bottlenecks, recurrent delay and unnecessary freight lifts; expanding capacity of freight corridors; constructing railroad grade crossings at vulnerable crossings and others. Operational improvement strategies include accelerating rapid incident response on priority freight corridors, implementing positive train control, and others. There is an emphasis on strengthening multi-state and multi-agency collaboration to achieve infrastructure and operational improvements. Policy guidance includes encouraging off-peak usage, expanding funding sources, prioritizing emission reduction projects and others.

Strategies are broadly described and not linked to project lists. There are no specific implementation targets or metrics to measure progress. Prioritization of projects is stressed several times regarding freight network location (network tiers), project type, priority goals and funding program requirements, but no specific priorities are set. The CFMP recommends identifying individual needs and solutions for better regional and sub-regional plan implementation, and transitioning California's freight system to a sustainable system consistent with CARB goals. Future work will focus on further developing strategies, criteria, and performance measures as part of a more coordinated approach to freight planning activities at the state, regional and local levels.

For the operational improvement strategies, the CFMP states that public-private relationships are integral, and communication capabilities are critical, including strengthening pre-disruption communication within the freight industry to prepare for recovery in order to fully address the subject of freight transportation resilience in the update to the CFMP. The public and private sectors must continue to work together to incorporate ITS into freight projects that are identified in state, regional and local plans. It is recommended that the efforts to address freight infrastructure and operations need to be judicious, balancing economic goals with the goals of safety, security, community and environmental stewardship.

There is a substantial need for a wide variety of freight-related research in California. The CFMP generates a list of potential topics, particularly statewide studies. One recommendation is to conduct a statewide assessment of warehousing capacity and distribution, with the findings serving as an amendment to the next version of the CFMP. Another recommendation is to track the condition and performance of the multimodal freight system across a wide range of attributes in order to: 1) document the effectiveness of investment goals and objectives; 2) identify the most effective measurement and approaches; and 3) determine to what extent they serve the intentions of their funding programs. The region's and state's extensive truck travel also requires focused tracking and reporting beyond the scope of the CFMP.

A qualitative assessment of implemented strategies requires a well-structured evaluation system. It is composed of three major parts: project impact assessment, project-strategy connection and strategy effective evaluation. Project impacts on economic, social and other aspects should be conducted with the support of a broad scope of data after tracking the implementation and effects of the project in both short term and long term. It would provide a solid foundation to assess the implemented strategies by combining the effects of a series of projects associated with certain strategies. The method of effectively connecting project impacts with strategies effects is another important part of the comprehensive evaluation system. This part is supposed to be well designed in the plan to make sure project and strategies are going to be tracked in the right scope. With the foundation of collective project impacts associated with the strategies, the evaluation system will regulate the long-term assessment of proposed strategies under the broad goals stated in the plan.

Apart from the absence of the comprehensive evaluation system, there is no available information on the base data to support any part of the assessment. For example, there is no project status information for the project impacts, no connection of projects to strategies and no supportive data for strategy evaluation. Therefore, we cannot conduct the qualitative assessment of implemented strategies in the plan at this stage.

3.4. Suggestions on Data for Updating the CFMP

Based on the above assessment, we present our suggestions for Caltrans consideration. To make the 2019 CFMP more comprehensive and feasible, we suggest completing the statewide freight transportation model, linking the local facilities inventory to the statewide inventory, and developing performance measures to evaluate strategy effectiveness.

3.4.1. Statewide freight transportation model

To update the existing CFMP to a more comprehensive plan, there is a need to generate a statewide 2040 forecast of freight supply and demand and the resultant freight traffic on the state highway system. The effort to develop a statewide freight transportation model is ongoing. It will be important to complete the model, validate it on baseline data, and test it for forecasting.

There are three factors that are changing rapidly and merit consideration in further developing the freight transport model. First, technology is changing quickly and facilitating efficiency improvements in the supply chain. This should lead to more full loads and fewer empty backhaul trips. Second, consumer e-commerce is growing very fast, and consumer expectations for almost instant deliveries are increasing. These demands are leading to restructuring of supply chains and increasing reliance on fulfillment centers close to population centers. Third, California's goals for zero emission freight vehicles imply new routing and distribution practices due to the limited range of these vehicles and the location of refueling stations.

3.4.2. Link the local facilities inventory to the statewide inventory

On the supply side, freight assets listed in the appendix on a local level should be restructured to create a statewide inventory of current freight supply. There should also be a forecast of 2040 statewide freight capacity. In this way, freight development challenges can be identified on state, regional and local levels and associated with the project list. For example, in the 2013 California State Rail Plan (CSRP), rail development demands are clearly identified by statewide, regional and local levels (section 7). Implementation status of proposed projects should be added to the project list to track progress. Based on that, with the support of numerous data of other sources including a series of economic and social development metrics, it would be possible to assess the effectiveness of projects, and therefore evaluate implemented strategies. For example, in the 2013 CSRP, table 8.8 lists planned investments by timeframe for the Pacific Surfliner Route. Planned investments could then be tracked and evaluated with the available project investment data, therefore, to examine the impacts of the strategies associated with a series of projects.

3.4.3. Develop performance measures for evaluating strategy effectiveness

A third suggestion is to develop performance measures for evaluating strategy implementation and effectiveness. There are no performance metrics in the current version either for projects or strategies. We suggest a comprehensive evaluation system to assess the effectiveness of the strategies by tracking project implementation. Based on the system described at the end of Section 3.3 in this report, we suggest the development of performance measures and indicators respectively for the evaluation on project implementation, project-strategy connection and strategy effectiveness. The performance measures can be developed separately to conduct the evaluation on a short-term, mid-term and long-term basis.

3.5. Conclusion

The 2014 California Freight Mobility Plan (CFMP) is the first statewide plan, and it was written in response to the requirements of MAP-21. The state had limited freight data and limited resources to launch a major planning process. Thus, the 2014 plan lacked a future statewide forecast, a comprehensive analysis of freight related congestion problems, or a prioritized list of statewide projects. It also relied primarily on secondary data sources. The freight planning conducted in the Los Angeles and San Francisco regions provides the state with comprehensive information on the two metro areas where most of the state’s freight activity is located. This information provides a potential building block for expansion to the other metro areas. In addition, the CSRP provides a good model for what the next CFMP could be.

Chapter 4: Public Outreach

4.1. Description of Webinar Outreach Process

As part of the agreement with Caltrans Office of Freight Planning and DRISI, it was decided that for the purpose and needs of the process of this study, to implement webinars instead of workshops.

Two public webinars were convened to gather information from stakeholders and the community on the expected impacts of freight, and possible mitigation strategies. The webinars were titled Addressing Congestion & Delays Caused by Freight and were streamed live from the University of Southern California (USC) on two separate occasions: May 23, 2017 and May 30, 2017.

The webinar presenters included Jose Marquez-Chavez, Senior Transportation Planner, Caltrans Office of Freight Planning, and Genevieve Giuliano, Director of the METRANS Transportation Center, USC. Mr. Chavez introduced the purpose of the webinar by explaining the connection between the California Freight Mobility Plan (CFMP) and the three new requirements in the FAST Act. He emphasized the importance of public input in the process of updating the CFMP and welcomed comments. Director Giuliano's presentation covered the research on identifying freight impacts; provided examples of freight impact bottlenecks in Los Angeles County, the San Francisco Bay Area and the rest of California; and offered potential mitigation strategies organized by infrastructure improvements, efficiency improvements, and policy incentives. She stated that major challenges are cost, collaboration across the supply chain and political support.

Jonathan Schwartz, USC Director of Video Productions and Operations, directed the webinar video process providing technical expertise and guidance. Catherine Showalter, METRANS Project Manager, coordinated the communications, registrations and reporting throughout the webinar development and implementation efforts.

Individuals registered online to view the webinar(s) via Eventbrite and were provided: 1) confirmation of their registration; 2) link to the webinar; 3) email address to submit questions or comments; and 3) reminder email the day prior to the webinar.

Comments were received through June 2, 2017. The registration process provided USC with a list of registered attendees with organization affiliation for reference during the webinars and email addresses for potential follow-up. That information was shared with Caltrans and updated on an ongoing basis as registrations were received via Eventbrite.

4.2. Results

For outreach efforts, in addition to posting webinar announcements on the Caltrans and METRANS websites, personal email invitations were sent by USC and Caltrans to transportation professionals in government, industry and academia.

May 23, 2017 – 51 minute broadcast

Total registered:	47 persons
Watched webinar:	26 persons
Average watch time:	26.16 minutes

May 30, 2017 – 56 minute broadcast

Total registered:	37 persons
Watched webinar:	31 persons
Average watch time:	16.49 minutes

Two written questions were received after the May 23 webinar and addressed during the May 30 webinar. One additional question was submitted on May 30 after the webinar had ended. Unfortunately, there were technical difficulties with Caltrans participants that impacted their participation. However the presentations were sent to each one of these participants, and they were able to watch them.

For the final product, since the presentations were almost identical with the same research shared, the webinars were combined, using the first session presentations with the combined questions and answers (Q&A) components from both sessions. Please see recorded webinar at the following links:

https://player.vimeo.com/video/219729505

http://www.dot.ca.gov/hq/tpp/offices/ogm/index.html

Webinar announcement, Webinar agendas, and Webinar PowerPoint presentations are included in Appendix B.

4.3. Description of CFMP Updates

Dr. Genevieve Giuliano participated in the California Freight Advisory Committee (CFAC) Meeting on May 24, 2017 to provide research updates on impacts of freight on congestion in the State of California. She presented a PowerPoint presentation which is available at the Caltrans CFAC site http://dot.ca.gov/hq/tpp/offices/ogm/cfac1.html.

Chapter 5: Review and Assessment of Mitigation Strategies with Recommendations

5.1. Introduction

The final task in this research is to identify potential mitigation strategies for the impacts of freight on the transportation system. Per the FAST Act provision, the emphasis is on congestion impacts. We conducted a comprehensive international review of mitigation strategies and assessed their applicability and effectiveness for freight problems in California. Our emphasis is on the statewide system and the major freight generators. Most of the large generators are in metropolitan areas and have significant impacts on surrounding communities. Thus, we include mitigation measures that address freight traffic in dense urban areas. We do not include strategies that are focused exclusively on emissions reductions, such as clean truck programs, as emissions reductions is not specifically identified in the FAST Act language. However, our mitigation measures take into account the State's emissions and GHG reduction goals.

Mitigation strategies can be categorized into three groups: 1) infrastructure improvements; 2) efficiency improvements; and 3) policy incentives. Infrastructure improvements (highway widening, grade separations) are aimed at increasing capacity, reducing conflicts, or facilitating use of other modes. By their very nature, infrastructure projects require long planning horizons and large funding commitments. Infrastructure strategies are constrained by limited financial resources, conflicts between proponents and opponents that play out through a lengthy environmental review process, lack of space or right-of-way, or environmental considerations.

Although each product supply chain is extremely efficient, the freight system as a whole is not. Freight industry actors have an economic incentive to operate as efficiently as possible, but they do not have an incentive to consider the impacts of their choices on others. Given the limited opportunities for infrastructure expansion in many parts of California, efficiency improvements are critical to mitigating freight congestion problems, and there are many opportunities for such improvements.

Technology will play a central role in increasing freight system efficiency. Information systems can effectively help manage traffic and incidents for all vehicles, and coordinate drayage pickups and route selection to reduce truck VMT and delay. Eventually the supply chain will become more transparent as more information is shared. The availability of information makes possible more extensive coordination across the supply chain. By 2040, it is anticipated that trucks will have some level of automation. It will be important to include strategies such as platooning for consideration.

Public policy plays an enormous role in the freight transport system. Tax policy, safety requirements, size and weight restrictions and many other policies create the framework in which freight industry actors make decisions. Public policy–through pricing or regulation–can incentivize efficiency improvements and environmental mitigation. However, limitations on the authority of the State to regulate interstate commerce and international ocean carriers, impose constraints on environmental regulation.

5.2. Selecting and evaluating mitigation strategies

There is an almost infinite number of possible strategies for mitigating freight impacts. We studied a pool of candidates by reviewing numerous academic studies, professional reports and documents, and selected the strategies that are consistent with CFMP goals and potentially effective in freight impact mitigation. We paid particular attention to those strategies that had been tested and implemented in the US or elsewhere in the world, so that we can analyze whether and how they could effectively achieve goals in the context of California. Meanwhile, we attempted to cover as much as we can—from infrastructure improvement to policy options—in our selection of strategies. These strategies may be adopted in different parts of California to solve different types of freight related problems according to local needs and conditions. Finally, this is by no means an exhaustive list of strategies for mitigating freight impacts. But we believe the list provides a good array of applicable options given the current state of public policy and technology.

Our selected strategies are described in detail below and then evaluated based on the following four criteria: cost, effectiveness in reducing truck-related congestion, co-benefits, technical difficulty, and implementation feasibility. Cost includes capital costs, maintenance costs, and other costs incurred in the implementation of each strategy. Co-benefits refer to benefits other than freight impact alleviation such as safety or emissions reductions and these benefits are consistent with California's sustainability goals. Technical difficulty considers whether the required technologies exist or are expected to exist within the planning timeframe, and whether design or construction involves technical challenges. Implementation feasibility considers institutional supports and barriers, public perceptions, and industry perspectives. We use a simple metric of high, medium and low for each criterion, with high meaning best or greatest likelihood of success. Our evaluation is based on our research, policy experience, and professional judgment. The results of our evaluation are presented at the end of each group of strategies.

5.3. Mitigation strategies

5.3.1. Infrastructure improvements

5.3.1.1. Truck-only lanes

Truck-only lanes are highway lanes designated for the use of trucks. The main purpose of such lanes is to separate trucks from other mixed-flow traffic to reduce the impacts of truck flows on passenger traffic and enhance safety (Caltrans, 2017[7]). Truck-only lanes can provide additional capacity for truck traffic, allow for tolling, and provide a protected facility for truck platooning. In spite of these advantages, truck-only lanes are seldom built in the US as their disadvantages are equally significant. The construction of truck-only lanes is very costly given the high standards of pavement needed for accommodating heavy truck movement (Fischer, Ahanotu, and Waliszewski, 2003). Second, right-of-way (ROW) availability is limited, especially in dense urban areas. Third, there is no consensus on who should pay for the high costs of truck-only lanes/highways (Forkenbrock, and March, 2005). Finally, some question the effectiveness of truck-only lanes, since they would be underutilized during off-peak hours (Fischer, Ahanotu, and Waliszewski, 2003; De Palma, Kilani, and Lindsey, 2008). Truck-only lanes may be only justified in very high volume truck corridors (Forkenbrock, and March, 2005).

California currently has two truck-only facilities; these are on Interstate 5 where grades are steep and truck traffic volume is relatively high. The State of Georgia has recently approved truck-only lanes on Interstate 75, a heavily travelled freight corridor south of Atlanta.[8] This project continues to be controversial and was challenged by the Georgia Department of Audits, and has yet to be scheduled for construction. Truck-only lanes have been part of the I-710 Corridor studies for at least a decade. However, no alternative acceptable to all stakeholders has yet been identified. Building truck-only lanes requires significant funding and is justified only where truck volumes are high. In California, they must comply with emissions reduction goals. Therefore, applicability of truck-only facilities in California is limited.

5.3.1.2. Railroad grade separations

Railroad grade separations are an effective way to reduce the impacts of freight rail on arterial traffic by eliminating at-grade conflicts between rail and vehicular traffic. Roads with grade separation allow traffic to move with no interruptions from freight rail movement, reducing traffic delays and risk of accidents (Gitelman et al., 2006). Railroad grade separations tend to be

[7] http://www.dot.ca.gov/trafficops/trucks/truck-only-lanes.html
[8] https://www.trucks.com/2016/05/02/georgia-plans-truck-only-roadway-to-fight-traffic/

space-intensive and costly, because of the costs of building bridges or tunneling under the rail right-of-way. Grade separations are widely recognized as an effective strategy for mitigating the impacts of high volume train corridors. For instance, the Alameda Corridor East project is primarily a grade separation project. Several railroad grade separations have been constructed, most notably the Colton Crossing. The Colton Crossing is the intersection of the tracks for the Union Pacific and the BNSF in the City of Colton, California. The proposal of building a flyover to grade separate the two tracks was presented by the Alameda Corridor Transit Authority in 2006 for the purpose of reducing train crossing conflicts and hours-long congestion. The project was completed in August 2013 with the final cost of $93 million. It is estimated to produce time savings for passengers and shippers valued at $241 million and reduced GHG emissions by 31,000 tons annually (OneRail Coalition, 2014). Other projects are planned at crossings with severe delays and collision threats.

The main problems with grade separations are financial. Railroads are generally unwilling to pay for the separations, because they provide no benefit to the railroad. The public views grade separations as the responsibility of the railroads, because the trains are the cause of delay and accidents on the street system. Further, there is no dedicated fund for grade separations. Colton Crossing was funded by state and federal sources including $34 million from American Recovery & Reinvestment Act stimulus funds and $41million from a 2006 transport bond, with contributions from UP and BNSF (Railway Gazette, 2013). ACE has encountered delays as a result of the lack of funding availability. However, with new funding sources in the FAST Act and SB1 in California, financial barriers may be reduced.

5.3.1.3. Expand highway capacity

Expanded highway capacity allows for a larger volume of all vehicles, thus reducing traffic delays that may result from heavy truck flows. Additional highway lanes can potentially be used as toll lanes; we have several operating examples of toll lanes, including the I-110 and I-10 in Los Angeles County, and SR 91 in Orange County. If toll lanes are reserved for passenger vehicles, the shift of passenger vehicles out of general purpose lanes would free up capacity for trucks.

The main challenges for adding highway capacity include lack of right of way, cost, and the possibility of latent demand generating more overall travel (e.g. Noland, 2001), especially in already congested metropolitan areas. Although toll lanes are gaining more acceptance, it remains a political challenge to obtain sufficient public support. For example, a proposed HOT lane on the I-405 in Orange County was defeated by local political leaders in favor of a toll free carpool facility that opened in 2016.

Adding more highway capacity without tolls is a potential problem, as any induced traffic would counter California's VMT reduction goals under AB 32 and SB 375. Therefore, expanded highway capacity could only be justified in high growth areas with insufficient highway infrastructure. These expansions could potentially reduce impacts of freight flows, although they would not be planned for that purpose.

5.3.1.4. Truck parking facilities

Federal and state hours of service requirements determine when long-haul drivers must stop and rest. According to a 2011 survey by the American Transportation Research Institute (ATRI), hours of service was identified as the second most pressing trucking issue. Truck parking has been a problem of particular seriousness in California. In 2012, California was ranked first in commercial vehicle parking shortage among all states in the US. Demand exceeds capacity at all public rest areas and 88% of private truck stops along 34 of California's corridors with the highest volumes of truck travel (California Department of Transportation, 2012). FHWA data suggests that in 2015, California had only 55 truck parking spaces per daily 100,000 truck VMT, which is the third worst shortage in the nation, behind only Hawaii and Rhode Island. The problem is most significant on the I-5 (Sells, 2015). The parking shortage is expected to get worse, given predictions of growing demand for goods movement (Heinitz and Hesse, 2009). Increasing the supply of truck parking would allow drivers better scheduling of rest stops, reduce illegal truck parking, and reduce drivers' exceeding driving hours. Thus, increasing parking would increase safety.

There are many challenges to increasing truck parking supply in California. First, areas with the most serious shortages are often located in or near the major metropolitan areas, where land availability is extremely limited. Second, the demand far exceeds Caltrans' truck parking budget, and not enough private facilities have come online. Third, a financial model for supporting truck parking facilities has yet to be established. Although truck drivers are the beneficiaries of parking facilities, it is not clear that drivers or their companies are willing to pay for the costs of building and operating these facilities. On the other hand, there may be more cost-effective innovative solutions. For example, there may be opportunities for shared use. The vast parking lots of suburban shopping centers are empty at night; it might be possible to use them for night truck parking.

Table 5.3-1 shows the assessment results of infrastructure improvement strategies.

Table 5.3-1 Qualitative assessment of infrastructure improvement strategies

Strategy / Criterion	Infrastructure improvements			
	Truck-only lanes	Railroad grade separations	Expand highway capacity	Truck parking facilities
Cost*	Low	Low	Low	Low
Effectiveness	High	High	High	High
Co-benefits	High	Medium	Medium	High
Technical difficulty	Medium	Medium	Medium	Low
Implementation feasibility	Low	Medium	Low	Medium

*Rating is with respect to likelihood of success

5.3.2. Efficiency improvements

As noted earlier, there are many possibilities for efficiency improvements that would reduce truck VMT and hence contribute to congestion reduction.

5.3.2.1. Freight advanced information management systems

The application of Intelligent Transportation Systems (ITS) in freight movement can bring about great benefits to both the logistics industry and the entire society. Freight traffic management systems integrate ITS technologies including two-way communication, location and tracking devices, electronic data interchange, and advanced planning and operation decision support systems (Crainic, Gendreau, and Potvin, 2009). With these technologies, freight traffic management systems collect data from stakeholders and provide advice on better routing and time scheduling. These systems can produce society-wide benefits including reduced traffic delays, and increased supply chain efficiency. ITS would also help reduce emissions and other impacts on neighboring communities, reduce energy consumption, and increase safety.

One example of a freight management system is the Freight Advanced Traveler Information System (FRATIS). It has been a successful and promising program, and it so far has three demonstrations implemented in Southern California, Texas, and South Florida, and several analogous tests in cities such as Memphis, Tennessee. The benefits of installation of the FRATIS are found consistent with expectations. The test results in Memphis confirmed that the program reduced the number of bobtail trips (i.e., empty-return loads) by 10 percent, terminal queue times by 20 percent, travel times by 15 percent, fuel consumption by 5 percent and level of criteria pollutants and GHG by 5 percent (Jensen, Fayez and DeSantis, 2015). The Southern California demonstration case showed similar results: daily mileage, time and stop time per order dropped substantially after the installation of the FRATIS system (Troup, 2014).

Although the FRATIS demonstrations show the potential of such systems, there are challenges to large scale adoption and implementation. First, reliable funding sources need to be identified to cover the high capital and maintenance costs of such systems. Currently the funding is primarily from USDOT demonstration funds, and a long term funding strategy has not yet been identified. Second, private firms must be willing to participate, and participation means sharing proprietary data. There have been difficulties in recruiting volunteers even for the demonstrations. Over time, technology development should solve this problem by developing ways to anonymize data, screen out critical data, and improve data security. Third, a scaled up system requires a designated system operator and participation of all the relevant state and local agencies. The institutional structure of such a system has yet to be identified.

5.3.2.2. Integrated freight load information systems

A key tool for achieving coordination across the supply chain is integrated information systems. An integrated freight load information system is one where the status (location, contents, origin, destination) of every shipment is known to all relevant supply chain participants. Efficient data sharing ensures stakeholders within the system the ability to monitor and operate different elements of the supply chain in consistent steps, and respond to adjustments quickly and effectively. In response to demands for more efficient supply chains, there is evidence that greater supply chain coordination is now occurring at all levels. In the case of port-related supply chains, for example, steamship lines now coordinate vessel stowage of individual containers at the port of origin and port of departure to expedite unloading and processing (Mongelluzzo, 2016).

At present, a system to track cargo from end to end exists, however it exists in a piecemeal fashion and in most cases has yet to be stitched together. Existing applications of integrated freight load information systems can be categorized by these tasks: 1) matching a load with a carrier, 2) order acceptance, 3) dispatching/routing, 4) pick-up/delivery confirmation, 5) transmitting shipping documentation, and 6) cargo manifesting (National Research Council, 2003). Currently in-use representative software includes:

- Director Fleet Software monitors position and operation of fleet vehicles and equipment

- Tailwind TMS Software manages revenue for trucking companies
- Navis N4, a container terminal operating system, conducts port facility planning and control (Navis, 2015).

Though these systems have greatly increased the efficiency of some links of the supply chain, they are not fully integrated and are developing in (mostly incompatible) pieces. To date there has been no coordinated effort to track cargo in a systematic way. There are no information standards and no requirements for interoperability across different software or operating systems.

A fully integrated system would require a common information platform that includes a central server that stores the data, database tools to manage and update data, a streaming capability to receive and process data in real-time, and APIs (application program interface) for interacting with the database to allow for web service querying of the data. It would require a manager and set of protocols regarding what data are stored and for how long, who gets access to the system, protection of proprietary data, storage of the data, data security, who pays to develop, maintain and operate the system, and other operating considerations. It would need a host acceptable to and trusted by all parties.

There are a number of implementation challenges for an integrated freight load information system. First, there is no institutional structure in place to lead the development of such a system and manage its operation, nor do we have examples of how such a system would be financed and maintained. The information technology infrastructure and databases would involve significant up-front costs as well as high maintenance and operation costs, which would be difficult to sustain in practice (Han, Wang & Naim, 2017). Second, specialized, proprietary software exists and is growing rapidly. It would be difficult to establish standards and protocols and apply them "ex-post." However, it is possible that new data integration techniques could solve the disparate data problem. Third, an integrated system relies on sharing proprietary data, yet firms may not see sufficient benefits to be willing to share (Gunasekaran & Ngai, 2004). Finally, an integrated information system would have to comply with security requirements (protection of data and protection of the public from terrorist risk).

5.3.2.3. Freight priority traffic management

In areas with large volumes of truck traffic, a traffic management system that gives priority to trucks can result in net reductions in delay for all traffic. Truck priority reduces the frequency of acceleration and deceleration for trucks. Because heavy trucks have much slower acceleration and deceleration rates than autos or light trucks, they impose delay on the upstream traffic. Reducing truck delay therefore reduces total delay when truck volumes are a large share of the total traffic. A recent simulation modeling study found that freight signal priority (FSP) reduces travel delay of freight vehicles by up to 26% (Kari et al., 2014). The benefits of FSP depend on truck volumes and traffic patterns.

Freight signal priority (FSP) requires Vehicle-Infrastructure Integration (VII), so that signal timing can be adjusted in real time in response to approaching traffic and instructions can be communicated to vehicles (e.g. to reduce speed and avoid a stop). Of course, VII is required for many traffic management strategies and for achieving the envisioned benefits of automated vehicles. Thus, the infrastructure costs of VII would be spread across many applications.

The success of FSP relies on support from both the public and private sectors. Public funding is needed to install, operate and maintain the system. The logistics industry would need to invest in instrumenting the truck fleet. There is no freight priority traffic management system deployed in the US yet, but the system has potential to effectively mitigate freight impacts.

5.3.2.4. Cargo matching services

Cargo matching refers to allocating transport resources (drivers, vehicles, routing etc.) to efficiently achieve cargo movement in the freight network. (Nieberding, Apfelstandt & Dashkovskiy, 2017; Cohn, Root & Mohr, 2007). Drayage trucking is subject to significant inefficiencies due to container and chassis repositioning requirements as well as queuing at port terminals. Currently the common practice is to transport empty containers back to the terminals. The non-revenue generating trips increase VMT and lower the overall network efficiency. To minimize empty trips, load matching strategies have been developed and have gained some success in various regions (Jaller et al, 2016; Guericke & Tierney, 2015).

Strategies include matching empty containers with cargo, first come first take pickups, and developing platforms to match available chassis with containers. From the implementation experience, the main limitation for matching empties with loads is the cost to transport the empty containers to the cargo, which could be $200-300 per movement. The high cost constrains the private freight operators from moving forward. Therefore, an incentive program initiated by the public sector could increase the likelihood of successful matching services. The first come first take pickups can work well for large operators with a high volume of cargo. For small operators less-than-truckload (LTL) trucking with relatively low efficiency is more likely (Jaller et al, 2016).

An effective way to match containers with cargo is through a unified platform with high level transparency providing information for all levels of operators. These types of technology platforms allow participation from carriers, manufacturers and distributors, freight forwarders, 3PLs, brokers, or businesses that regularly or sporadically have freight needs (Medda, & Trujillo, 2010; Wanke & Falcão, 2017). Key benefits from these technologies are the ability to provide information about unused capacity, asset visibility and reduction of "dead head" miles or empties (Jaller et al, 2016). Available examples include Flexport facilitating international freight forwarding, Cargomatic finding LTL, full truckload or drayage freights, and UberRush focusing on last-mile delivery. Though the platforms are already technically feasible, there is still a long way to go to have them widely utilized in the industry due to the requirement of information sharing and collaboration among stakeholders.

5.3.2.5. Smart truck parking

As noted in the previous section, California has a serious shortage of truck parking. Although more efficient use of the existing supply will not fully compensate for this shortage, it can help to make the best use of it. Smart truck parking includes a variety of strategies such as providing information on available spaces along the trucker's route and allowing advance reservation of spaces. As the truck fleet diversifies, smart truck parking systems could provide information on alternative fuel or charging stations.

Many private Intelligent Truck Parking services have emerged in recent years. Representative applications include the Truck Smart Parking Services (TSPS) which provides real-time parking availability information, park reservations and lot management services (http://www.trucksmartparkingservices.com/), and the American Truck Parking system launched by the Transportation Sustainability Research Center (TSRC) at the University of California Berkeley, which generates forecasts of truck parking availability based on historical data collected from sensing systems placed at truck stops (http://www.americantruckparking.com/).

Taking the I-5 corridor as an example, Caltrans partnered with NAVTEQ, ParkingCarma™ and TSRC on a pilot program. Real-time truck parking availability and reservation capabilities have been integrated into the truck parking mapping and routing services provided by ParkingCarma™. The total number of spaces available in each truck parking facility is keyed into the reservation and check availability engines (Shaheen and Rodier, 2007). Truck drivers are able to access this truck parking information as well as directions to parking facilities by phone (511 or 800 number), websites (both Internet and WiFi), satellite radio and mobile apps. Therefore, truck drivers can plan trips with planned stops and reduce VMT generated by searching.

Another pilot project is being led by CARB. In addition, the number of private players is expanding, both in supplying parking and parking apps. Each has different (and incompatible) software and information infrastructures. In order to be as effective as possible, a smart parking system must be statewide, use common technology, and address the State's parking shortage. Integrated smart parking requires a common information and technology platform so that truckers will need only one "app" to access all parking options, public or private. It would appear that currently there are at least two platforms in development. If truckers must invest in learning and using multiple systems, they are less likely to use them at all. Integration is important as the heavy duty vehicle fleet changes; it will be important to distribute power stations, etc., according to demand, and to make such information easily accessible.

5.3.2.6. Off-hours deliveries

Trucks both cause and suffer from congestion in urban areas. Deliveries made during the business day in congested areas cost us all— wasted time, lost revenue, missed deliveries and parking tickets (New York City, 2010). To reduce the impacts of the congestion, the idea "Off-hours deliveries (OHD)" was proposed to shift some deliveries to off-peak hours (or outside general business hours), targeting congestion reduction, better air quality and a more sustainable use of existing freight system capacity (Holguín-Veras et al, 2006). Although OHD is an obvious solution for shifting freight deliveries out of the peak period, it faces many challenges, including noise impacts, on-time deliveries, and the additional costs imposed on receivers (Browne et al, 2006).

In 2009, an OHD pilot program was conducted in New York City with funding from USDOT (New York City, 2010). Results showed that travel speeds from the truck depot to delivery drivers' first stop in Manhattan improved by up to 75% compared to the evening rush hours, while subsequent trips averaged travel speeds up to 50% faster. With less competition for parking spaces, trucks spent only 30 minutes stopped at the curbside making deliveries, instead of 100 minutes before the pilot. From beginning to end, delivery routes averaged 48 minutes faster during the pilot (New York City, 2010). The pilot received positive feedback from receivers and carriers, who claim to continue the strategy even without the public subsidy. Meanwhile, few complaints were received.

OHD programs have been launched in several cities around the world, but not yet in California. OHD would be most suitable for the largest and most congested city cores, Los Angeles and San Francisco. Typically OHD programs require subsidies, as receivers incur additional costs by keeping facilities open through a night shift. The subsidies are justified by the reduction in congestion and emissions that results from shifting freight traffic to night hours. There is ongoing research on technologies that would allow for secure deliveries at closed facilities, but these are not yet market ready.

5.3.2.7. Terminal appointment systems

There are many delays in the drayage process: congestion on roadways, queuing at terminal gates, queuing or waiting to drop off or pick up, queuing or waiting at the destination. Appointment systems are intended to reduce truck queuing, increase velocity of container movement, and reduce container dwell time. Appointment systems target productivity and efficiency at port terminals via the implementation of information and communication technologies (Giuliano, et al. 2008; Morais & Lord, 2006).

An appointment system provides time windows for drayage transactions (pick up, drop off). The basic system would have an information platform that informs shippers of container, chassis and space availability. Shippers select a time window for the transaction, and a truck is dispatched to arrive during the time window. Appointment systems have potential benefits for both terminal operators and truckers and shippers. Appointments allow terminal operators to optimize utilization of resources. If terminal operators know in advance which containers are being picked up or dropped off, they can better manage truck flows and container moves within the terminals. The ability to predict gate moves allows for the more efficient ordering and use of longshore labor. Appointments would also translate to shorter turn times for truckers, as less time would be spent waiting for a container to be available. Appointments could also be used to meter truck arrivals to prevent congestion on the dock. There is an extensive literature based on simulation studies that consistently show productivity benefits via increased throughput, gate efficiency, and equipment utilization, as well as reduced wait and turn times (Moras and Lord, 2006; Huynh and Walton, 2008; Namboothiri and Erera, 2008; Huynh, 2009, Zhao and Goodchild, 2013).

There are many appointment systems operating around the world, but there is only one port-wide system. Vancouver established its appointment system in 1999 (Morais & Lord, 2006). In Vancouver the government played a significant role in establishing the port-wide program via regulation of both the terminals and the drayage industry. At the Ports of Los Angeles and Long Beach, there is discussion that the PierPass group, which currently operates the PierPass program, may take the lead in a port-wide program. We recommend a port-wide appointment system that would operate across all terminals using a single information platform. It would include coordination of gate entries and dock transactions so that there would be little truck queueing or idling on the dock.

There are some significant implementation challenges for a port-wide system: 1) terminal operators and shippers/truckers have different objectives for an appointment system; 2) a port-wide system requires common infrastructure and operational practices, but terminals have different infrastructure and operating practices; 3) unreliability of truck travel times due to heavy regional congestion would affect appointment system efficiency.

5.3.2.8. Truck platooning

If trucks could operate with shorter following distance in high truck volume corridors, it would be possible to increase truck throughput. Truck platoons take advantage of communications technology to set common speeds and headways among several trucks traveling in the same direction. The technology and communications requirements of platoons can vary. In the simplest case, dynamic cruise control and communications between vehicles can facilitate platooning of two or three vehicles. A more automated system, with self-driving trucks, would require both vehicle-to-vehicle and vehicle-to-infrastructure communications. Truck platoons could increase the capacity of roads, reduce traffic congestion and fuel consumption, shorten travel time, and improve traffic safety. The major downsides of the technology include the high costs of developing the highway infrastructure, as near-term platooning would require a separate right of way to avoid the problems of other traffic entering the platoon.

Truck platooning has been studied and tested in the USA and Europe. In 2013, the Federal Highway Administration funded two projects. The Driver-Assistive Truck Platooning (DATP) initiative study is led by Auburn University. Partners include the American Transportation Research Institute; Meritor Wabco, a leading supplier of braking and safety systems; Peloton Technology, the creator of a system combining radar and DSRC communications; and truck manufacturer Peterbilt Motors Company. The team released its Phase One final report in August 2015, and the results show that platooning would not negatively impact traffic flows, and could improve traffic flows if truck market penetration reached 60 percent (Fierro, 2015). The second project led by the California Department of Transportation, Volvo Group of North America and U.C. Berkeley demonstrated truck platooning on the I-110 Freeway in Southern California in March, 2017. In Europe, the Netherlands organized a European Truck Platooning Challenge, during its Presidency of the European Union in 2016. The challenge involved trucks from six manufacturers, and its first major journey was completed in April 2016. While the Platoon Challenge demonstrated the potential of its technology, there remain many questions regarding regulation and implementation (Vincent, 2016).

The potential for widespread, full scale platooning remains uncertain. Truck platoons make sense in high density, longer distance corridors; we do not yet know the extent of this market. The technology is less challenging in a protected environment, meaning truck only lanes, and truck only lanes can be financially justified only in the highest density corridors. Absent a protected right of way, truck platoons face many challenges, including the entry of other vehicles into the platoon, how drivers would or could respond to the equivalent of a “train of trucks” on a highway, and how access and egress to/from the highway is to be managed.

Table 5.3-2 shows the assessment results of efficiency improvement strategies.

Table 5.3-2 Qualitative assessment of efficiency improvement strategies

Strategy / Criterion	Efficiency improvements							
	Freight advanced information management systems	Integrated freight load information systems	Freight priority traffic management	Cargo matching services	Smart truck parking	Off-hours deliveries	Terminal appointment systems	Auto truck platoon
Cost	High	High	Low	High	High	High/Low	High	High
Effectiveness	High	High	Medium	High	High	Medium	High	High
Co-benefits	High	High	Medium	High	Medium	Medium	High	High
Technological difficulty	High	High	Medium	High	High	Medium	High	Medium
Implementation feasibility	Medium	Medium	Medium	High	High	Medium	High	Medium

*Rating is with respect to likelihood of success

5.3.3. Policy incentives

Public policy has enormous influence on the transportation sector through the provision of infrastructure, the level of fuel taxes and fees, fuel and emission regulations, size and weight limits, hours of service, and a host of other policies. In this section, we identify policies that could have a significant effect on freight flows.

5.3.3.1. Truck and passenger VMT tax

A vehicle tax based on miles traveled provides a direct incentive for more efficient travel. Travelers would be charged for the maintenance and operation of the infrastructure in proportion to the quantity used. A VMT tax has many benefits: 1) it would reduce VMT, all else equal, 2) it is a promising option for replacing the fuel tax as conversion of the fleet to alternative fuels proceeds, and 3) it could generate new revenue for the highway system. A VMT tax could be structured to be revenue neutral for the trucking industry by adjusting fuel and excise taxes. It could also be structured to reflect the greater damage trucks impose on highway infrastructure. With VII technology, a variable VMT tax is possible; the rate could be increased on congested facilities. On the other hand, a VMT tax could face strong political opposition. The implementation of the tax could be challenging given the complicated system of charging the tax and other issues including privacy protection.

Distance-based fees for heavy trucks have been widely adopted in Europe, but not in the US. Oregon was the first state in the US to conduct pilot projects for passenger vehicles. As of this writing, the VMT tax is offered as a voluntary program through the Oregon state DOT. Pilots are either planned or in progress in several other states. California has conducted the Road Charge pilot program with 5,000 volunteers. Results of the project are pending. None of these involve heavy trucks.

The major challenge to VMT taxes or any other type of direct user charge strategy is political opposition. The pilot programs have been aimed at showing that concerns such as privacy and data security or incurring overall higher taxes can be addressed. However, to date, no state legislature has authorized a universal (rather than voluntary) VMT tax. The trucking industry can be expected to oppose VMT taxes unless they are revenue neutral to the industry, or they result in significant infrastructure improvements (for example truck only lanes or increased truck parking).

5.3.3.2. Truck lane tolls

Truck-only toll lanes have not yet been implemented in the US. As noted above, the Atlanta region has approved truck toll lanes on I-75, but the project remains controversial and has not yet been funded. Truck-only lanes are part of the alternatives being considered for the I-710 Corridor, and some are proposed as toll lanes. As also noted earlier, truck-only lanes would separate truck and general traffic, provide added capacity, and likely increase safety. As with any single use facility, truck lanes would require a high level of demand to be justified.

Tolls are typically used for two reasons: to manage congestion, or to provide a source of revenue. Newly built truck-only lanes are unlikely to be congested, and high tolls would divert traffic to other routes, unless a region-wide pricing system was implemented. Thus, truck-only toll lanes would likely have low tolls, which would contribute some revenue, but not enough to cover the construction costs.

Successful implementation would require collaboration and communication between the public sector and the private sector. Careful assessment would be needed to determine the level of potential demand and sensitivity to toll rates. In corridors with very high truck volumes, truck-only toll lanes are potentially an effective strategy to reduce freight impacts.

5.3.3.3. On-site parking and loading

Local freight deliveries are essential to the functioning of a city (Dablanc, Giuliano, Holliday & O'Brien, 2013) and the great majority of urban freight is delivered by trucks (Reisman & Chase, 2011). The conflict between freight delivery and passenger parking increases in dense urban areas. The growth of consumer e-commerce is adding to the problem by generating more residential deliveries. Truck parking is difficult in these areas due to zoning and vehicle size restrictions. In addition, high land prices deter land developers from using their property for on-site delivery facilities. The result is extensive illegal parking (Amer & Chow, 2017). Three major impacts are generated: 1) safety -- truck-bicycle crashes as truck drivers often park on bike lanes; 2) more congestion and delay; 3) increased time and financial cost for deliveries (Marquis et al, 2016). Parking prohibitions are ineffective because the carriers are willing to pay the fine rather than search for a more distant parking space. Efforts to redesign the streets without consideration of urban truck parking space and delivery routes defeat the purpose of creating bike lanes and more pedestrian friendly street environments (Giuliano & Hanson, 2017).

Urban planners historically have given little attention to goods movement circulation in designing new communities or approving infill development. Incorporating truck circulation, parking and loading space in site plans for dense urban areas would help to prevent truck delivery problems (Marcucci & Scaccia, 2015). This requires zoning with more comprehensive consideration of both passenger and freight traffic (Kawamura & Sriraj, 2016). Legal space for truck parking and loading will reduce search time, processing time and economic cost for truck drivers. Legal spaces (either on or off site) would avoid conflicts and reduce the risk of crashes (Amer & Chow, 2017). New York City, Tokyo, Barcelona and many other dense urban areas have revised zoning codes to accommodate delivery needs. For example, New York has updated its on-site parking and loading restrictions for that purpose. Double parking is allowed at certain locations and during certain hours for making pickups, deliveries or service calls (New York City, 2017). However, the related cost would be imposed on property owners especially in high-density areas with high land value (Chen, Conway & Cheng, 2017).

Table 5.3-3 shows the assessment results of policy incentive strategies.

Table 5.3-3 Qualitative assessment of policy improvement strategies

Strategy / Criterion	Infrastructure improvements		
	Truck and passenger VMT tax	Truck lane tolls	On-site parking and loading
Cost*	Low	High	Medium
Effectiveness	High	High	High
Co-benefits	High	Medium	High
Technical difficulty	Medium	Medium	Low
Implementation feasibility	Low	Low	Medium

*Rating is with respect to likelihood of success

5.4. Conclusion

This chapter has presented fifteen strategies to mitigate freight impacts. We reviewed research papers and professional reports on freight impact mitigation, and selected strategies that best achieve our goals and can potentially be implemented in California. We organized these strategies into three categories: 1) infrastructure improvements; 2) efficiency improvements; and 3) policy incentives.

For each strategy, we identified its major advantages and disadvantages, assessed the scenarios that the strategy can be justified, and presented existing examples if possible. Our assessment criteria include cost, potential for freight impact mitigation, political feasibility, and technological difficulty to implement. Tables 5.3-1 to 5.3-3 summarize the assessment results. To compare these strategies, we further use general rankings of high, medium, and low. All assessments are relative to one another (e.g. "high" means high relative to the other strategies). We stress that these are highly subjective ratings given that many strategies have not been in practice and limited information is available. In general, infrastructure improvement strategies are likely to incur high costs, in terms of both capital costs and maintenance costs; efficiency improvement strategies require adequate technological support; and policy incentive strategies may encounter strong political pressure. The potential for freight impact mitigation varies across strategies. In different contexts, states and local authorities should consider strategies that best fit their resources and goals. The review and assessment of these strategies can help the State develop programs to mitigate growing impacts of freight movement on the transport system.

References

AECOM, Cambridge Systematics, Inc. and Arellano Associates (2013). 2013 California State Rail Plan. Prepared for California Department of Transportation.

Amaruchkul, K., & Lorchirachoonkul, V. (2011). Air-cargo capacity allocation for multiple freight forwarders. Transportation Research Part E: Logistics and Transportation Review, 47(1), 30-40.

Amer, A., & Chow, J. Y. (2017). A downtown on-street parking model with urban truck delivery behavior. Transportation Research Part A: Policy and Practice, 102, 51-67.

Bilgen, B., & Günther, H. (2010). Integrated production and distribution planning in the fast moving consumer goods industry: A block planning application. OR Spectrum, 32(4), 927-955.

California Department of Transportation (2012). Fast Freight Facts: Commercial Vehicles (Trucks). California Department of Transportation. Retrieved from: http://www.dot.ca.gov/hq/tpp/offices/ogm/fact_sheets/Fast_Freight_Facts_Trucks_bk_040612.pdf

California Department of Transportation (2018) 2018 California State Rail Plan: Connecting California. Available at http://www.dot.ca.gov/californiarail/docs/CSRP_PublicReleaseDraft_10112017.pdf

California Department of Transportation & California State Transportation Agency (2014). California Freight Mobility Plan, accessed 1/22/17. Available at http://www.dot.ca.gov/hq/tpp/offices/ogm/cfmp.html

Cambridge Systematics, Inc. and Battelle Memorial Institute (2005). An initial assessment of freight bottlenecks on highways. Prepared for Federal Highway Administration Office of Transportation Policy Studies.

Cambridge Systematics, Inc. (2014). San Francisco Bay Area Freight Mobility Study. Prepared for California Department of Transportation.

Chen, Q., Conway, A., & Cheng, J. (2017). Parking for residential delivery in New York City: Regulations and behavior. Transport Policy, 54, 53-60.

Cohn, A., Root, S., Wang, A., & Mohr, D. (2007). Integration of the load-matching and routing problem with equipment balancing for small package carriers. Transportation Science, 41(2), 238-252.

Crainic, T. G., Gendreau, M., & Potvin, J. Y. (2009). Intelligent freight-transportation systems: Assessment and the contribution of operations research. Transportation Research Part C: Emerging Technologies, 17(6), 541-557.

Dablanc, L., Giuliano, G., Holliday, K., & O'Brien, T. (2013). Best practices in urban freight management: Lessons from an international survey. Transportation Research Record: Journal of the Transportation Research Board, (2379), 29-38.

De Palma, A., Kilani, M., & Lindsey, R. (2008). The merits of separating cars and trucks. Journal of Urban Economics, 64(2), 340-361.

Ecola, L., & Light, T. (2009). Equity and congestion pricing. Rand Corporation, 1-45.

Fierro, D. (August 19, 2015). U.S. DOT releases study findings on platooning initiative. Retrieved from https://www.truckinsurancenitic.com/company-news/446-u-s-dot-releases-study-findings-on-platooning-initiative.html

Fischer, M., Ahanotu, D., & Waliszewski, J. (2003). Planning truck-only lanes: Emerging lessons from the Southern California Experience. Transportation Research Record: Journal of the Transportation Research Board, (1833), 73-78.

Fleger, S. A., Haas, R. P., Trombly, J. W., Cross III, R. H., Noltenius, J. E., Pecheux, K. K., & Chen, K. J. (2002). Study of Adequacy of Commercial Truck Parking Facilities-Technical Report (No. FHWA-RD-01-158,).

Forkenbrock, D. J., & March, J. (2005). Issues in the financing of truck-only lanes. Public Roads, 69(2).

Garber, N. J., Wang, H., & Charoenphol, D. (2002). Estimating the supply and demand for commercial heavy truck parking on interstate highways: a case study of i-81 in Virginia (No. FHWA/VTRC 03-R4,). Virginia Transportation Research Council.

Gitelman, V., Hakkert, A. S., Doveh, E., & Cohen, A. (2006). Screening tools for considering grade separation at rail-highway crossings. Journal of transportation engineering, 132(1), 52-59.

Giuliano, G., & O'Brien, T. (2007). Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. Transportation Research Part D: Transport and Environment, 12(7), 460-473.

Giuliano, G., O'Brien, T., Zhou, J., & Lei, T. (2008, January). Impacts of port gate operations on the highway system: A case study. In The 87th Transportation Research Board Meeting: Washington DC.

Giuliano, G., O'Brien, T., Dell'aquila, P., & Hayden, S. (2008). Evaluation of the Terminal Gate Appointment System at the Los Angeles/Long Beach Ports. METRANS Transportation Center, Project 04-06. Final Report. University of Southern California.

Giuliano, G., & Hanson, S. (2017). Chapter 14 Looking to the Future. The Geography of Urban Transportation, 4th Edition. Guilford Press.

Guericke, S., & Tierney, K. (2015). Liner shipping cargo allocation with service levels and speed optimization. Transportation Research Part E: Logistics and Transportation Review, 84, 40-60.

Gunasekaran, A, & Ngai, Ewt. (2004). Information systems in supply chain integration and management. 159(2 SPEC. ISS.), 269-295.

Han, S., Zhao, L., Chen, K., Luo, Z. W., & Mishra, D. (2017). Appointment scheduling and routing optimization of attended home delivery system with random customer behavior. European Journal of Operational Research, 262(3), 966-980.

Han, J. H., Wang, Y., & Naim, M. (2017). Reconceptualization of information technology flexibility for supply chain management: An empirical study. International Journal of Production Economics, 187, 196-215.

Heinitz, F., & Hesse, N. (2009). Estimating time-dependent demand for truck parking facilities along a federal highway. Transportation Research Record: Journal of the Transportation Research Board, (2097), 26-34.

Holguín-Veras, J., Pérez, N., Cruz, B., & Polimeni, J. (2006). Effectiveness of financial incentives for off-peak deliveries to restaurants in Manhattan, New York. Transportation Research Record: Journal of the Transportation Research Board, (1966), 51-59.

Holguín-Veras, J., Wang, C., Browne, M., Hodge, S. D., & Wojtowicz, J. (2014). The New York City off-hour delivery project: lessons for city logistics. Procedia-Social and Behavioral Sciences, 125, 36-48.

Huynh, N. and Walton, C.M. (2008). Robust scheduling of truck arrivals at marine container terminals. Journal of Transportation Engineering 134(8): 347–353.

Huynh, N. (2009). Reducing Truck Turn Times at Marine Terminals with Appointment Scheduling. In Proceedings of Transportation Research Board 09, Washington.

Irving, D. (2013). Why you won't pay a toll to drive 405 anytime soon. The Orange County Register. Retrieved from http://www.ocregister.com/2013/12/10/why-you-wont-pay-a-toll-to-drive-405-anytime-soon/

Jaller, M., Bird, A., Christensen, M., Shimoda, C., Nam, A., Lee, K., Line, M., & Fretheim, E. (2016). Strategies to Maximize Asset Utilization in the California Freight System: Part II – Strategies. A White Paper from the Freight Efficiency Strategies Development Group co-published by National Center for Sustainable Transportation & Institute of Transportation Studies at University of California Davis. Jensen M., Fayez S. and DeSantis S. (2015). Los Angeles-Gateway Freight Advanced Traveler Information System – Demonstration Team Final Report. FHWA-JPO-14-197. Retrieved from http://ntl.bts.gov/lib/54000/54800/54838/FHWA-JPO-14-197_la_dtfr.pdf

Kari, D., Wu. G., and Barth, M. (2014). Eco-Friendly Freight Signal Priority using connected vehicle technology: A multi-agent systems approach. Proceedings of the 2014 IEEE Intelligent Vehicles Symposium Proceedings, Dearborn, MI, June 8-11.

Kawamura, K., & Sriraj, P. S. (2016). Building freight-friendly environment. Transportation Research Procedia, 12, 119-131.

Killough, K. (2008, January). Value analysis of truck toll lanes in Southern California. In 87th Annual Meeting of the Transportation Research Board, Washington, DC Conference CD Paper (No. 08-0140).

Marcucci, E., Gatta, V., & Scaccia, L. (2015). Urban freight, parking and pricing policies: An evaluation from a transport providers' perspective. Transportation Research Part A: Policy and Practice, 74, 239-249.

Marquis, R., Wang, Xiaokun Cara, Ban, Xuegang Jeff, Conway, Alison, & Wallace, William (2016). Increasing the Understanding of Truck Parking Behavior in Congested Urban Areas: Behavioral Data Acquisition and Analysis with Cumulative Prospect Theory, ProQuest Dissertations and Theses.

Martin, E. W., & Shaheen, S. A. (2012). Truck Parking and Traffic on I-5 in California: Analysis of a Clipboard Survey and Annual Average Daily Traffic Data.

McMullen, B. S., Zhang, L., & Nakahara, K. (2010). Distributional impacts of changing from a gasoline tax to a vehicle-mile tax for light vehicles: A case study of Oregon. Transport Policy, 17(6), 359-366.

Medda, F., & Trujillo, L. (2010). Short-sea shipping: an analysis of its determinants. Maritime Policy & Management, 37(3), 285-303.

Meyer, M. D. (2006). Feasibility of a metropolitan truck-only toll lane network: The case of Atlanta, Georgia. Georgia Transportation Institute, Georgia Institute of Technology.

Mongelluzzo, B. (2016, January 7). US ports investing billions to expand operations to improve efficiency. Journal of Commerce. Retrieved from http://www.joc.com/port-news/usports/us-ports-investing-billions-expand-operations-improve-efficiency_20160107.html

Morais, P., & Lord, E. (2006). Terminal appointment system study (No. TP 14570E).

Namboothiri, R. & Erera, A.L. (2008). Planning local container drayage operations given a port access appointment system. Transportation Research Part E, 44, 185-202.

National Research Council (2003). Committee on Freight Transportation Information Systems Security. Cybersecurity of Freight Information Systems: A Scoping Study (No. 274). Transportation Research Board Computer Science and Telecommuting.

NAVIS (2015). NAVIS N4 Brochure. Retrieved from http://navis.com/sites/default/files/pages/docs/n4_brochure_3.1_2015.pdf

Neiberding, B., Apfelstädt, A., & Dashkovskiy. S. (2017). Cycles as a Solving Strategy for Matching Problems in Cooperative Full Truckload Network. IFAC-PapersOnline, 50(1), 7941-7946.

New York City (2010). Off-Hour Deliveries Program. http://www.nyc.gov/html/dot/html/motorist/offhoursdelivery.shtml

New York City (2017). Parking a Truck or Commercial Vehicle. http://www.nyc.gov/html/dot/html/motorist/parktruck.shtml

Noland, R. B. (2001). Relationships between highway capacity and induced vehicle travel. Transportation Research Part A: Policy and Practice, 35(1), 47-72.

OneRail Coalition (2014). Success Stories in Rail Investment: Colton Crossing California. Retrieved from http://www.onerail.org/sites/default/files/documents/success-stories/onerail-success-stories-colton-crossing-ca-12-2-14.pdf

Phan, M. H., & Kim, K. H. (2016). Collaborative truck scheduling and appointments for trucking companies and container terminals. Transportation Research Part B: Methodological, 86, 37-50.

Railway Gazette, (August 29, 2013). Colton Crossing grade separation completed. Retrieved from http://www.railwaygazette.com/news/single-view/view/colton-crossing-grade-separation-completed.html

Reisman, A., & Chase, M. (2011). Strategies for Reducing the Impacts of Last-Mile Freight in Urban Business Districts. UT Planning.

Schrank, D., Lomax, T., & Eisele, B. (2011). TTI's 2011 urban mobility report. Texas A&M Transportation Institute. The Texas A&M University System.

Sells J. (2015) California Sustainable Freight Action Plan: Pilot Project Idea – Reduced Emissions through Efficient Parking for Trucks. California Air Resources Board. Retrieved from: http://www.arb.ca.gov/gmp/sfti/sfpp/sfpp-020.pdf

Shaheen, S., & Rodier, C. (2007). Commercial Vehicle Parking in California: Exploratory Evaluation of the Problem and Possible Technology-Based Solutions.

Short, J., & Murray, D. (2014). Congestion Impact Analysis of Freight-Significant Highway Locations 2014. Prepared for the American Transportation Research Institute.

The Los Angeles Coalition (2016). Mitigating Congestion in the Central Terminal Area at LAX. Available at http://www.thelacoalition.com/economic-updates/weekly-report-may-16-2016-mitigating-congestion-central-terminal-area-lax/.

Troup, K. (2014). FRATIS Assessment Update. CDM Smith Assessment Team, North River Consulting Group, and Booz Allen Hamilton. Retrieved from http://www.fhwa.dot.gov/planning/freight_planning/talking_freight/july_2014/talkingfreight07_16_14kt.pdf

Vincent, J. (April 7, 2016). Self-driving truck convoy completes its first major journey across Europe. Retrieved from https://www.theverge.com/2016/4/7/11383392/self-driving-truck-platooning-europe

Wanke, P., & Falcão, B. B. (2017). Cargo allocation in Brazilian ports: An analysis through fuzzy logic and social networks. Journal of Transport Geography, 60, 33-46.

Wang, H., Zhang, X., & Wang, S. (2016). A joint optimization model for liner container cargo assignment problem using state-augmented shipping network framework. Transportation Research Part C: Emerging Technologies, 68, 425-446.

Zhang, X., Zeng, Q., & Chen, W. (2013). Optimization model for truck appointment in container terminals. Procedia-Social and Behavioral Sciences, 96, 1938-1947.AECOM, Cambridge Systematics, Inc. and Arellano Associates. (2013) 2013 California State Rail Plan. Prepared for California Department of Transportation.

Zhao, W. and Goodchild, A. (2013). Using the truck appointment system to improve yard efficiency in container terminals. Maritime Economics & Logistics, 15, 101-119.

Appendix A: Current and Expected Impacts of Freight

Appendix B: Public Outreach

Webinar invitation

Webinar agendas

Webinar PowerPoint presentations