Reason

Reason Foundation
Policy Study No. 447
November 2015

Increasing Mobility in Southern California: A New Approach

by Baruch Feigenbaum

Reason Foundation

Reason Foundation's mission is to advance a free society by developing, applying and promoting libertarian principles, including individual liberty, free markets and the rule of law. We use journalism and public policy research to influence the frameworks and actions of policymakers, journalists and opinion leaders.

Reason Foundation's nonpartisan public policy research promotes choice, competition and a dynamic market economy as the foundation for human dignity and progress. Reason produces rigorous, peer-reviewed research and directly engages the policy process, seeking strategies that emphasize cooperation, flexibility, local knowledge and results. Through practical and innovative approaches to complex problems, Reason seeks to change the way people think about issues, and promote policies that allow and encourage individuals and voluntary institutions to flourish.

Reason Foundation is a tax-exempt research and education organization as defined under IRS code 501(c)(3). Reason Foundation is supported by voluntary contributions from individuals, foundations and corporations. The views are those of the author, not necessarily those of Reason Foundation or its trustees.

Reason Foundation

Increasing Mobility in Southern California: A New Approach

By Baruch Feigenbaum

Executive Summary

Productive regions offer mobility for people and goods, but Southern California's productivity is seriously threatened by reduced mobility. Without fundamental policy change, congestion and the lack of quality transit service threaten to strangle the region's economy. The ability to move goods and services efficiently, combined with the need to provide a high quality of life for employees and their families, should put improving mobility at the top of Southern California's priorities. The consequences of ignoring this growing problem will be severe.

The L.A. region, contributing the most congestion to Southern California, has been the nation's most congested metropolitan area for decades. The cost of congestion—as measured in wasted time and fuel—is estimated at $13.3 billion per year, or $1,711 per commuter annually. Average annual hours of delay per traveler have increased from 52 in 1985 to 80 in 2014. The travel time index (the ratio of travel time during peak periods to the same trip off-peak) increased from 1.31 to 1.43 during the same period. As population and employment in the region continue to grow, these numbers will get even worse unless new measures to reduce congestion are implemented.

While the region continues to spend significant resources on new rail lines, Southern California residents are taking fewer transit trips per capita today than 20 years ago. Transit-dependent residents must rely on a smaller bus network that fails to adequately serve their needs.

This study examines Southern California's mobility challenges in detail. While the Southern California Association of Governments' (SCAG) Long Range Transportation

Plan includes some new capacity, it does not allocate nearly enough resources to improving mobility. The region's planned transportation approach of investing heavily in fixed-rail transit and land-use changes to reduce the extent of driving can benefit the region but the approach will not significantly reduce traffic congestion or improve transit service in Southern California. The current plan would lead to only a modest increase in transit's market share, while overall congestion would continue to increase. While non-automobile alternatives—including a larger and better-designed bus network, sidewalks for walking and a bike network for commuting—definitely have an important role to play, they alone cannot reduce congestion.

The new approach we recommend is a comprehensive plan to improve mobility. It reduces congestion by dealing with both major sources: recurrent and non-recurrent. For non-recurrent congestion, which is caused by incidents (accidents, work zones, weather, etc.), Southern California should expand efforts under way, such as quicker identification of, response to, and clearance of incidents. On arterial streets, improvements in traffic signal coordination and access management will also help.

For the remainder of congestion that occurs seven days a week in Southern California for up to 16 hours a day, some roadway system expansion is needed because demand greatly exceeds roadway capacity. Doing so in a smarter and more sustainable way can reap the greatest benefits. While rebuilding some of the most congested interchange bottlenecks is a part of the plan, the most important component is using variable (time-of-day, demand-sensitive) pricing on all new expressway lanes to keep them free from congestion, similar to the SR 91 and I-10 express lanes.

We also recommend adding electronically priced bridges and/or tunnels on selected arterials to permit vehicles to bypass traffic signals at major intersections. These bridges/tunnels, combined with intelligent transportation system (ITS) features and access management, would give arterial users the option of faster, less-congested travel on these busy highways. Creating a network of these express lanes and electronic toll lanes is a cost-effective way to improve the entire roadway network.

It is crucial to improve the transit network as well. Our express lane network allows buses to travel in the lanes free of charge, and our managed arterial network allows buses to use the tolled grade separations for free. Using these premium features will decrease the travel times and increase the reliability of BRT (bus rapid transit) and express bus. We also provide details on how to build on the success of the region's express bus network and L.A. Metro's BRT-lite system. Combined with local bus, express bus and the existing rail options, the region can create a bus-based transit system with the quality and coverage a rail-based system cannot provide.

These approaches will also provide commuters with more choices. If they need the flexibility of the automobile, they can use the general purpose lanes for free or pay to use the free-flowing express lanes. If they want to take transit, they can choose fast, reliable region-wide bus rapid transit and express bus. This approach assures commuters and other travelers of faster and more-reliable travel choices within a financially feasible and sustainable system.

From a revenue perspective, tolling—a major part of our plan—contributes significant resources to the biggest projects. Tolling would help build approximately 710 lane-miles of new expressway capacity, 3,475 new/converted lane-miles of express lanes and truck toll lanes, and 559 new managed grade separations. The tolled facilities will generate approximately $362 billion in toll revenue over the infrastructure's life cycle, providing more than 100% of the total revenue needed to build and operate the tolled components (new expressways/tunnels, express toll lanes and components, managed arterials and components), while providing a contingency in case costs are higher than forecast or revenue is lower.

This study identifies many infrastructure improvements. Table ES1 below lists our plan's major capital components and their anticipated costs. Figure ES1 presents a full map of our plan.

Table ES1: Reason's Plan for Southern California Region Congestion Relief

Component	Total Cost Year of Expenditure (nominal)
New surface expressways/tunnels	$97.2B
Expressway interchanges reconfiguration	$4.1B
Arterial/local road capital	$74B
Arterial interchange reconstruction	$15.6B
Express toll lanes	$105.0B
Express toll lane interchanges	$24.0B
Managed arterials widening(s)	$16.5B
Managed arterials optional tolled grade separations	$33.7B
Managed arterials new alignments	$2.9B
Toll contingency	$32.5B
Transit capital/bus	$42.7B
Roadway operations and maintenance	$90.5B
Transit operations and maintenance	$102.4B
Intelligent transportation systems	$10B
Active transportation	$7.7B
Transportation demand management	$5.2B
Debt service	$50.1B
Total	**$714.1B**

Figure ES1: Reason's Plan for Southern California Congestion Relief

Adjusted for inflation, our plan requires $352 billion in taxpayer resources while SCAG's plan needs $606 billion. As a result our plan can be constructed with current resources; no tax increase is needed. SCAG's plan needs to find an additional $254 billion over 25 years. Our plan to use tolling supports more improvements than SCAG's plan, even with a tax increase.

To reduce the risks inherent in our tolling projects (express lanes, managed arterials, new toll expressways/tunnels), we recommend that they be carried out under long-term concession agreements in which the private sector partners would bear the risks of cost overruns and revenue shortfalls. Public private partnerships (P3s) of this scale are being successfully employed in Colorado, Florida, Texas, Virginia and around the world.

Implementing this approach would generate significant economic benefits. Reduced travel times allow employers to recruit from a larger area and employees to seek jobs within a larger area, better matching skills with needs. The direct result of increase in quantity and quality of employment makes an urban area's economy more productive.

Individual motorists would benefit every day, as future trip times would shorten. With a network of uncongested express toll lanes on the entire expressway system, everyone with a transponder would have the peace of mind of knowing that he or she had a time-saving option available whenever it was crucial to get somewhere on time.

As noted, the network of uncongested express toll lanes and managed arterials can facilitate a large expansion of transit services. The region's transit providers would gain the virtual equivalent of a network of exclusive busways, since the priced lanes would permit reliable, free-flowing bus operations at all times. Yet unlike rail transit projects, for which funding is constrained, the infrastructure cost of this busway system would be paid for by motorists. This would give the region new options for corridors where it has become increasingly difficult to fund planned new rail lines. Also helpful would be development of a region-wide mobility center to coordinate bus routes and demand-response service for the elderly and disabled, as well as for residents of low-density areas, to create a seamless transportation network.

Southern California has come to a crossroads in transportation policy. Continuing down the status-quo path will lead to a future with an incomplete rail transit system and an undersized highway system, resulting in much worse congestion than today. The path suggested in this study accepts the reality that cars will continue to dominate personal transportation, trucks will remain the backbone of goods movement, and buses will be the mainstay of transit systems. It therefore would expand the multimodal highway infrastructure in smart, new ways to cope with those realities. This path promises a future of significantly less congestion than today, and of new mobility options—for motorists, for transit users, and for goods movement.

“Congestion results from poor policy choices and a failure to separate solutions that are effective from those that are not,” said former Transportation Secretary Norman Mineta. We hope Southern California will make wise policy choices for greatly increased mobility.

Table of Contents

Acknowledgment: This policy study is the independent work product of Reason Foundation, a nonprofit, tax-exempt research institute headquartered in Los Angeles. It was funded by the Galvin Foundation, as part of a multi-year, multi-state project to focus urban transportation policy on reduction of serious congestion.

Part 1

Southern California's Mobility Problem

According to the *2015 Urban Mobility Report* from the Texas A&M Transportation Institute, the greater Los Angeles region's average annual delay per traveler reached 80 hours in 2014.[1] The Los Angeles metro area's travel time index is 1.43 (meaning it takes an average of 43% longer to travel during peak periods than outside peak periods). Metro Los Angeles is worst in the country in both measures. In fact, Los Angeles is more congested than any other metro area in the United States, United Kingdom, France, Germany, Belgium and the Netherlands.[2]

Future prospects are not encouraging. With the end of the Great Recession, congestion is worsening throughout the country.[3] And despite a declining growth rate and a major rail expansion program, Southern California's traffic congestion has remained substantially worse than every other urban area in the country.

Business leaders are very concerned with Southern California's congestion problem. According to a recent study titled *Employer Views of Traffic Congestion*, congestion in the Los Angeles region is so bad that many employers are considering relocating to other areas.[4] The greater metro area is one of the few in the country that has lost jobs over the past 20 years. California also has one of the lowest labor force participation rates of any state in the country.[5] While some of these economic issues are due to the region's economic base and regulation, many of them are due to impaired mobility. Specifically, traffic congestion is such a problem that many employees seek to live exceptionally close to their jobs. But demand that exceeds housing supply results in increased home prices in certain areas. Many employees with the skills and abilities to relocate have migrated to less-congested areas where they can buy cheaper houses located farther from their jobs, such as Atlanta, Austin, Dallas, Houston, Miami, Phoenix and even Seattle.[6]

Finding more effective and sustainable methods of managing existing transportation assets and financing new infrastructure is the fundamental challenge faced by state and local decision-makers serving regions plagued by chronic traffic congestion. The social and economic costs of traffic congestion are staggering and continue to mount, as regions struggle to find better ways to expand inadequate transportation infrastructure to meet current and future travel growth. This is particularly true in the vast geographic area of Southern California.

Among other objectives, this study seeks to develop practical, cost-effective solutions to the region's traffic congestion. Our aim is to offer local decision-makers a menu of innovative multimodal strategies to improve regional mobility and system performance. This report identifies opportunities to address the region's mobility problem through a combination of strategies, including innovative engineering, value pricing, public-private partnerships, and innovations in performance and management. We hope this mobility study will provoke and inspire further, more-detailed research.

A. Southern California Congestion Is Different

What makes the congestion problem in the urban Southern California area so severe? The region's congestion problems stem from its high suburban population density, an expanding population, limited growth in highway and arterial road capacity, geographic barriers such as the Hollywood Hills, and a lack of funding for core infrastructure.

In more basic terms the Southern California urban area is both spread out, with numerous activity centers located far apart from each other, and also densely populated, with the highest population density of any major urban area nationwide. While the common image of Los Angeles is a sprawling metro area where residents drive up to 50 miles one way to work, the reality is far different. Metro Los Angeles is 12% denser than nearest competitor, San Francisco, 32% denser than metro New York, and far denser than other Sunbelt metro areas, including Houston (L.A. is 135% denser) and Atlanta (L.A. is 310% denser).[7] L.A. area commuters travel some of the shortest home-to-work *distances* in the country. It is this condition of "dense sprawl" that results in the high levels of congestion unmatched by any other region in the country. As stated in a Los Angeles report, "Los Angeles differs from other metropolitan areas in that people here travel in all directions. They don't just travel from the suburbs to downtown. There are many centers of employment, recreation and residence. And, the vast majority of residents do not use transit. The lack of a clearly identifiable commute pattern, combined with being one of the most densely populated urban areas in the country, makes the task of planning transportation for Los Angeles extremely complex."[8]

Table 1: Very Large Urbanized Area Commuting Facts

Metro Area	Urbanized Area Density (people per square mile)	Average Travel Time to Work (in minutes)	Average One-Way Commuting Distance (in miles)
Los Angeles	6,999	28.2	8.8
San Francisco	6,266	28.3	8.0
New York	5,319	34.8	7.7
Chicago	3,524	31.0	10.0
Washington, D.C.	3,470	33.1	9.1
Houston	2,979	27.8	12.2
Dallas	2,879	26.2	12.2
Philadelphia	2,746	28.3	7.8
Boston	2,232	29.0	N/A
Atlanta	1,707	30.2	12.8

Source: U.S. Census Bureau, American FactFinder Tables GCT-PH1, Brookings Institution

As defined for purposes of this study, Southern California consists of Los Angeles and Orange Counties, as well as the western portions of Riverside and San Bernardino Counties and the eastern portions of Ventura County. In this large geographic area, primary destinations are varied and widely dispersed. The share of employment located in downtown Los Angeles is modest when compared to other significant regional employment hubs, such as Westwood, Century City, Santa Monica, Woodland Hills, Glendale, Pasadena, Long Beach, and Torrance. And those are just in Los Angeles County. Much of L.A. metro's employment is located in Orange County, particularly Irvine, Anaheim, Santa Ana and Costa Mesa. As such, the number of commuter trips between counties is high as residents seek less expensive housing in San Bernardino, Riverside and Ventura Counties while they work in Los Angeles and Orange Counties. The same pattern is true of non-work trips, with medical, shopping and recreational centers located throughout the region.

Redevelopment opportunities will likely increase population density in the cores of Los Angeles and Orange Counties going forward. Nevertheless, the majority of future population and employment growth will occur outside of the inner core, in areas including north Los Angeles County (Santa Clarita, Lancaster, Palmdale), the eastern San Gabriel Valley, south Orange County, San Bernardino County, Riverside County and Ventura County.[9] The combination of high density and varied endpoints in Southern California results in long trip lengths and a high number of vehicle-miles traveled. The transportation system has struggled to handle this blend of characteristics, with numerous freeways and arterials being overloaded for eight or more hours each day.

B. Southern California Commuting Patterns

A lack of mobility is more than a nuisance. It hurts the economy, degrades the environment and harms residents' personal lives. Table 2 and Figure 1 show the metro Los Angeles commuter mode split and commuting patterns over four decades.

Table 2: Los Angeles Commute Mode Shares and Travel Times, 1980-2012

Travel Mode	1980 Share	1990 Share	2000 Share	2010 Share	2012 Share	Mean 2012 Travel Time (in minutes)
Total Workers	5,184,393	6,809,043	6,767,619	5,507,175	N/A	N/A
Total Auto	87.3%	87.8%	86.5%	84.2%	84.2%	N/A
Drive Alone	70.2%	72.3%	71.9%	73.4%	74.0%	26.9
Carpool	17.1%	15.5%	14.6%	10.9%	10.3%	29.7
Transit	5.1%	4.5%	5.6%	6.3%	6.2%	48.6
Bicycle	N/A%	0.7%	0.7%	0.9%	0.9%	N/A
Walk	3.5%	2.9%	2.7%	2.7%	2.6%	N/A
Work at Home	N/A	2.7%	3.5%	4.1%	4.8%	N/A

Source: American Fact Finder Table S0801, Means of Travel to Work

Figure 1: Percentage of L.A. Region Workers Who Commute to Work by Mode, 1990–2012

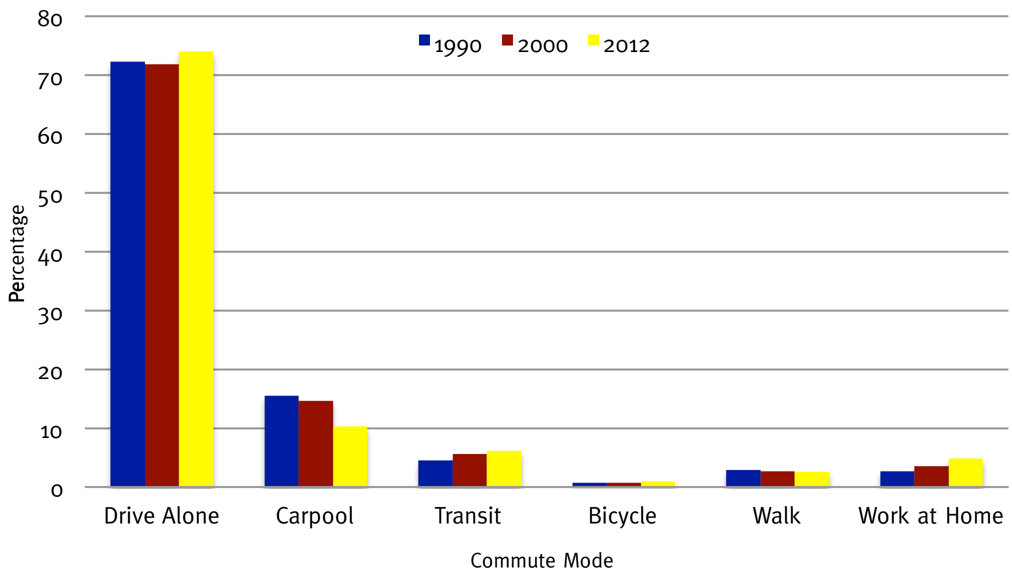


*Figure 1 uses numbers from Table 2

Table 2 and Figure 1 above show how L.A. metro area commuter mode shares and mean travel times by mode have changed from 1990 to 2012.

Driving continues to dominate commuting and accounts for 84.2% of the mode share by 2012. Since 1980, the estimated drive alone mode share in the greater L.A. area has increased from 70.2% to 74.0%, while the carpool mode share declined from 17.1% to 10.3%—representing a shift in traveler preference from carpooling to driving alone.

The transit mode share has increased from 5.1% in 1980 to 6.2% in 2012. However the transit share actually decreased between 2010 and 2012. More importantly, bus provides the vast majority of transit service, 4.8% of the 6.2%.[10] The "work at home" mode share has nearly doubled from 2.7% in 1990 to 4.8% in 2012. During that same time period, there has been a small increase in bicycling from 0.7% to 0.9% and a small decrease in walking from 2.9% to 2.6%. However, few people commute using active transportation so the actual numerical changes are very small.

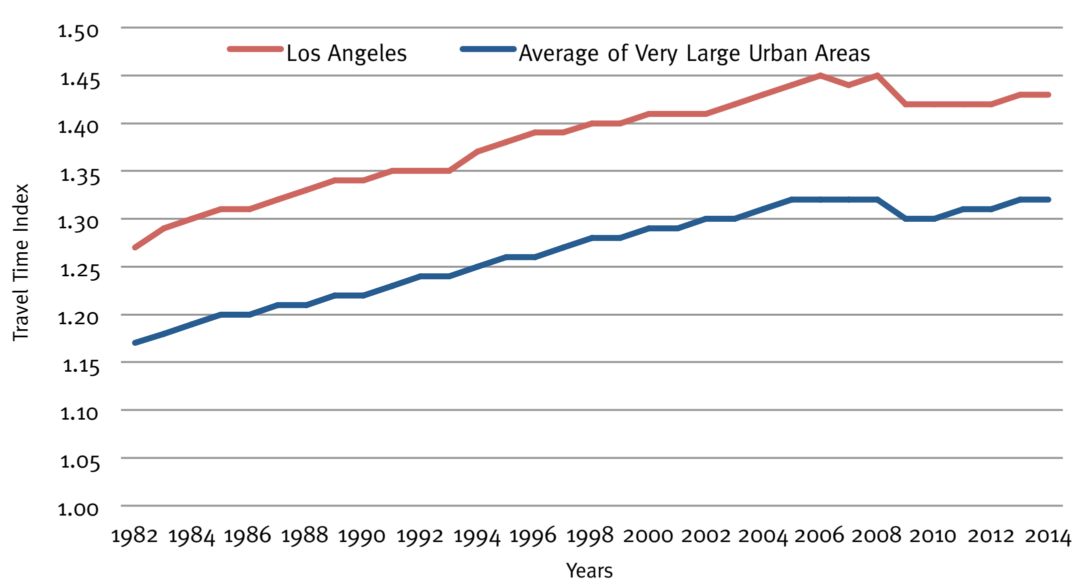
From the travel time data, it should be clear why the automobile mode shares are highest. Except for the short work trips that can be made by foot or on bicycle, driving provides by far the quickest trip, despite the added time due to congestion.

C. A Lack of Mobility

The current levels of traffic congestion in Southern California impose significant costs on individuals, businesses, and the regional economy.

Southern California has been the nation's leader in total traffic congestion for the past 25 years. In the year 2014, Los Angeles drivers spent an estimated 623 million person-hours sitting in congested traffic.[11] Currently, it takes 43% longer to travel in Los Angeles during peak periods, when congestion is severe, than during off-peak hours. Researchers at the Texas A&M Transportation Institute (TTI) define this as a Travel Time Index of 1.43. Figure 2 shows the trend in the Travel Time Index in Los Angeles over time, compared to the average of other very large urban areas (current regional population of over three million).

Figure 2: Travel Time Index, Los Angeles Urban Area vs. Very Large Urban Areas, 1982–2014

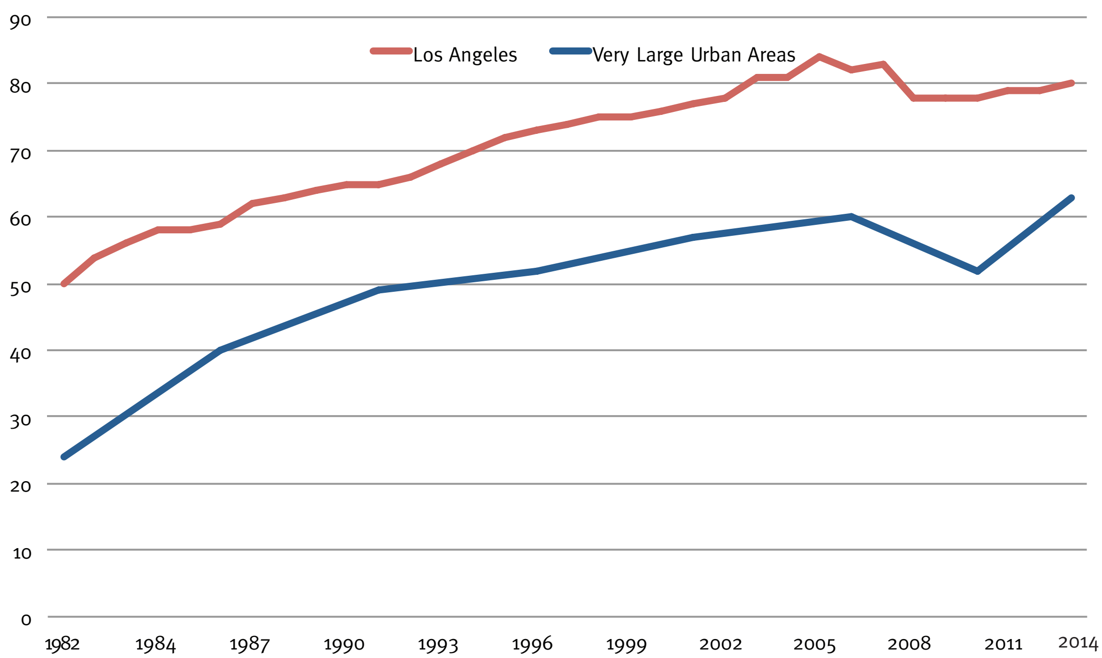


Source: 2012 Texas A&M Transportation Institute Annual *Urban Mobility Report*, 2015 Texas A&M Transportation Institute Annual *Urban Mobility Report*

The Travel Time Index in Los Angeles has been consistently higher than other major urban areas over time, having increased from 1.27 in 1982 to 1.39 in 2002, and to a record high of 1.43 in 2014.

Figure 3 shows the trend in average annual hours of delay in Los Angeles over time based on TTI data, compared to the average of other very large urban areas.

Figure 3: Annual Delay Per Peak Traveler, Los Angeles Urban Area vs. Very Large Urban Areas, 1982–2014

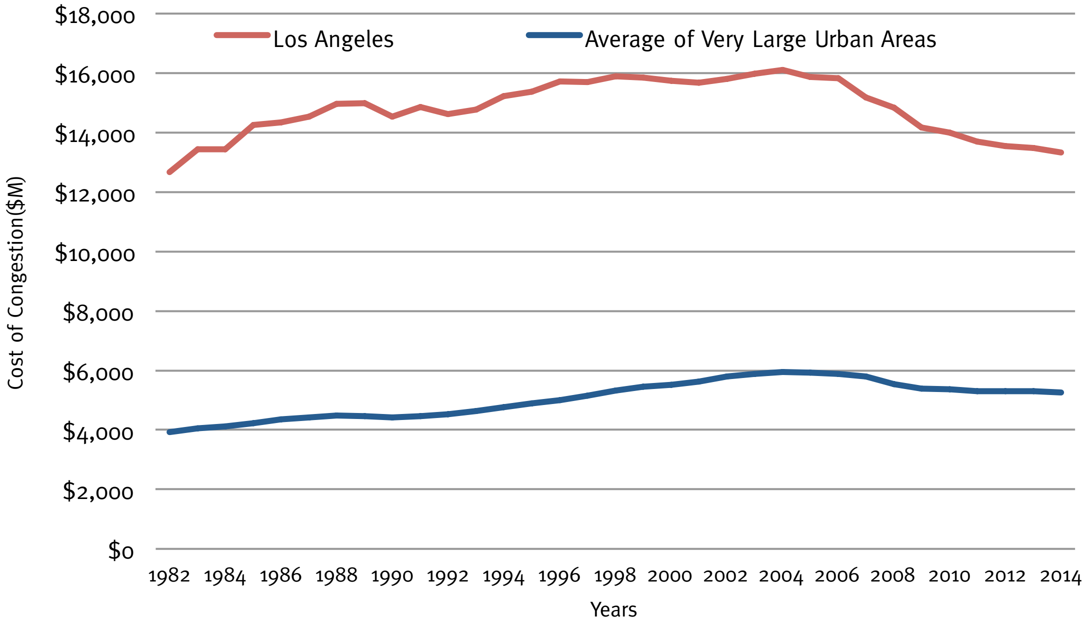


Source: 2012 Texas A&M Transportation Institute Annual *Urban Mobility Report*, 2015 Texas A&M Transportation Institute Annual *Urban Mobility Report*

The annual traveler delay in Los Angeles was 49% higher than the very large urban area average in 1985 (58 hours compared to 39 hours), 38% higher in 1995 (70 hours compared to 51 hours), 31% higher in 2002 (77 hours compared to 59 hours), 29% higher in 2011 (79 hours compared to 61 hours) and 27% higher in 2014 (80 hours compared to 63). Clearly, L.A. area travelers experience congestion levels that are significantly higher than those in other areas, a trend that has continued over time despite tremendous multimodal investments in the Southern California region's transportation system.

Figure 4 shows the trend in annual cost of congestion in the L.A. area over time, compared to the average of other very large urban areas.

Figure 4: Annual Cost of Congestion (millions), Los Angeles Urban Area vs. Very Large Urban Areas, 1982–2014



Source: 2012 Texas A&M Transportation Institute *Urban Mobility Report*, 2015 Texas A&M Transportation Institute *Urban Mobility Report*.

The region does not rank any better in other congestion measures. It is second worst in cumulative delay and delay per commuter.[12] It has the highest commuter stress index and freeway planning index—the amount of buffer time that needs to be factored in due to the unpredictability of congestion—in the nation. Since gridlocked traffic uses more gasoline than traffic operating at free flow speeds, Southern California drivers waste almost 200 million gallons of gasoline each year, second worst in the country.[13]

Even compared to the very largest areas, Los Angeles ranks poorly. Table 3 compares Los Angeles with some other major metro areas that have more than 5,000,000 residents.

Table 3: Comparison of Metropolitan Area Characteristics, 2014

Urban Areas	Population	Area (Square Miles)	Population Density (persons per sq mile)	Travel Time Index	Annual Hours of Delay	Annual Cost of Congestion (000s)	Annual Congestion Cost per Peak Traveler
Los Angeles	12,635,000	2,285	5,790	1.43	622,509,000	$13,318,000	$1,711
New York City	19,040,000	4,780	3,964	1.34	628,241,000	$14,712,000	$1,739
Chicago	8,700,000	2,800	3,073	1.31	302,609,000	$7,222,000	$1,445
Washington D.C.	4,920,000	1,310	3,521	1.34	204,375,000	$4,560,000	$1,834
Atlanta	4,500,000	3,050	1,430	1.24	148,666,000	$3,214,000	$1,130
San Francisco	3,480,000	1,270	3,229	1.41	146,013,000	$3,143,000	$1,675
Houston	5,000,000	1,905	2,167	1.33	203,173,000	$4,924,000	$1,490

Source: 2012 Texas A&M *Urban Mobility Report*; 2015 Texas A&M *Urban Mobility Report*

Los Angeles's annual congestion also has substantial economic costs. Annual congestion totals $13.3 billion in excess costs, or $1,711 per commuter.[14] In gasoline costs, this is the equivalent of driving an additional 12,221 miles per year with gasoline priced at $3.50 per gallon in a car that averages 25 miles per gallon. Truck congestion totals $1.7 billion, equating to $306 billion in truck commodity value. (Commodities are the products or goods transported by trucks. Truck commodity value is the total worth of all of the goods shipped by trucks.)[15] For comparison, $412 billion could buy a brand-new Toyota Camry for every man, woman and child in the Los Angeles metro area. Clearly there are significant economic costs to congestion.

The direct cost of congestion in metro Los Angeles in 2014 was enormous, at an estimated $13.3 billion. This cost has increased from $2.13 billion in 1982, $6.77 billion in 1992, and $10.8 billion as recently as 2011.[16] The current average cost of congestion in other very large urban areas is $5.3 billion, less than half of Los Angeles's $13.3 billion.

In one metric Los Angeles's congestion may not seem that bad. As the densest metro area in the country, the region has the 3rd shortest commute time of any major metro area. Yet, the region's commuters travel some of the shortest distances in the country. Some metro areas including Atlanta and Dallas have congested traffic because workers live far from their place of employment. Yet, the L.A. region's congestion is far worse than these cities, despite people traveling approximately half as far, on average.

The preceding numbers detail Los Angeles's congestion issues. But to actually fix the problem, we have to understand why the area's current system is not working.

Despite a robust network, because of its high densities, the L.A. area's expressway and surface arterial networks are severely overloaded. The following table compares the L.A. region's expressway and arterial data with other major metro areas. The L.A. figure for expressway VMT per lane-mile is the basic measure of how overloaded this region's expressways are, compared to those of other very large urban areas.

It is no mystery that L.A. area congestion is so severe. Furthermore, unlike some other metro areas, L.A. was already severely congested back in 1982. There is simply not enough roadway capacity for the huge amount of car, bus and truck travel needs of this huge, dense metro area. Figure 5 shows that even as L.A.'s daily vehicle-miles of travel increased by more than 100%, expressway lane-miles increased by less than 50%. Despite extensive congestion in 1982, over the next 30 years the agencies in charge chose not to significantly invest in adding capacity to keep pace with the growth in travel, resulting in the severe congestion conditions in the area currently.

L.A. regional congestion adversely affects transit as well. The backbone of the L.A. area transit network is bus service, with 77% of all transit passengers using bus as their primary transit vehicle rather than rail. Table 4 shows the commute choice in the automobile, rail transit and bus transit modes. In addition, many of those who use rail transit also take a bus to get to rail stations. Limited-stop, bus rapid transit and express bus are available as well as demand-response service for the elderly and disabled. All of these buses travel on roads, which are often congested. Reducing congestion would allow buses to travel their routes faster and more reliably, increasing the popularity of bus routes and allowing transit officials to decrease the headway between buses.

Reducing congestion would also allow suburban transit users who drive to commuter rail and express bus park-and-ride lots to have easier access to transit service, increasing transit usage. Severe congestion between their residence and the transit station might cause these choice riders, who can drive or take transit, to bypass transit for a quicker alternate route. Table 4 shows the split between driving and taking transit. The transit numbers are further divided into rail and bus. Some transit trips include bus and rail portions, so we chose the mode used for the majority of the trip.

Table 4: Los Angeles Region Commuter Mode Split

Mode	Total Commuters	Percentage of Total Commuters
Drive	5,474,045	85%
Bus	321,541	4.8%
Rail	39,771	1.4%
Other Modes (Telecommute, Bike, Walk)	N/A	8.8%

Source: U.S. Census, American FactFinder

As Table 4 shows, bus transit transports the majority of transit users. For every person who uses rail, eight people use bus.[17] As a result, congestion affects both the timeliness and reliability of the majority of transit trips.

Part 2

The Causes and Consequences of Lack of Mobility

A lack of mobility due to congestion is more than just a nuisance—it has real, negative consequences that stretch beyond arriving late at work. Understanding why and how congestion affects mobility starts with recognizing the two different types of congestion and their effect on the economy, the environment and the social sector.

A. Different Types of Congestion

Congestion is frustrating regardless of whether it is caused by an accident or routine peak period traffic volume. Transportation research identifies two primary types of congestion. Since they have different causes, they have different solutions. Understanding the differences between non-recurrent and recurrent congestion is vital for Southern California to reduce both types.

The first of these is what most people encounter every day on their trips to and from work—the overloading of the roadways with more vehicles than they can handle. Researchers refer to this as *recurrent* congestion, resulting from a basic mismatch of highway capacity with vehicles during peak periods. This type of congestion is costly—but at least it is predictable.

Non-recurrent congestion, which makes up as much as 50% of Southern California's total congestion, has many causes, including mostly unpredictable events (breakdowns and crashes), partially predictable events (weather) and very predictable events (construction work zones).[18] Since this incident-related congestion occurs randomly and without warning, it adds unreliability to trips. The rubbernecking resulting from a fender-bender may add 30 minutes to a 45-minute trip. When these incidents occur frequently, commuters often add extra "buffer time" to their trips. The Texas A&M Transportation Institute has recently added a planning time index to its standard measures of congestion to better ascertain the cost of such congestion.[19]

A recent National Cooperative Highway Research Program report examined the sources of congestion in very large urban areas such as Los Angeles. In most of these very large metro areas, about 50% of all traffic congestion is caused by incidents.

Table 5: Sources of Congestion in Very Large Urban Areas

Source of Delay	Percentage Contribution
Demand greater than capacity	37%
Poor signal timing	5%
Total Recurring Congestion	**42%**
Crashes	36%
Breakdowns	6%
Work zones	10%
Weather	5%
Special events, other	1%
Total Non-Recurring Congestion	**58%**

Source: The 21st Century Operations-Oriented State DOT

B. The Economic Costs of Congestion

The cost of congestion, which affects automobiles, truckers and transit vehicles alike, is measured by many different metrics. Specifically, congestion can increase bus travel times and reduce reliability, making transit significantly less appealing. The Texas A&M Transportation Institute (TTI) estimates direct congestion costs of approximately $160 billion nationwide.[20] However, this only accounts for the direct costs. The U.S. Department of Transportation estimates annual indirect congestion costs of $48 billion in 2014 due to productivity losses, another $48 billion due to unreliability, $4.8 billion due to cargo delay and $15.8 billion in safety and environmental costs. Combining both the direct and indirect costs, total congestion costs exceeded $275 billion ($276.6 billion) annually.[21]

Several years ago, the National Cooperative Highway Research Program (NCHRP) funded pioneering research attempting to get a handle on the cost of congestion to regional businesses.[22] They found that congestion interferes with just-in-time delivery systems, thereby increasing inventory costs. It reduces the availability of skilled workers, and raises payroll costs needed to attract such workers. It shrinks the market area for local firms' products and services, and it reduces the range of job opportunities for workers.

The NCHRP research team used Chicago and Philadelphia to gather data on logistic and labor market effects of congestion, with which to do some modeling. The team estimated that a 10% reduction in congestion would save businesses $1,274 million per year in Chicago and $312 million a year in Philadelphia in 2014 dollars.[23] They quantified labor market effects at an estimated $455 million in Chicago and $260 million in Philadelphia in 2014 dollars.

We have applied their research to Southern California to determine the economic effects of a 10% reduction in congestion. Such a reduction would save Southern California area businesses almost $2 billion per year. The labor market effects work out to more than $700 million per year in 2014 dollars.

Congestion affects the labor market because most people will not spend more than a particular amount of time each day on the journey to work. As congestion increases, the number of miles they can travel within this amount of time decreases. Imagine a person's home in the center and a range of employers, some five miles away, some 10 miles away and some 20 miles away. When congestion is low or zero, commuters can reach every point within a 20-mile circle, but in a highly congested region such as Southern California some people can only reach the points within the 10-mile circle. Others may be able to reach only points within the five-mile circle. According to basic geometry, the area of a 20-mile radius circle is four times that of a 10-mile radius circle. If work possibilities are randomly distributed across the landscape, the 20-mile circle will include four times as many job opportunities as the 10-mile circle. And the same applies in reverse for an employer. It will have four times as many potential employees within a 20-mile circle as a 10-mile circle.

In a large and diverse metro area, economic productivity depends on matching skilled employees with employers who can make the best use of their abilities. When Remy Prud'homme and Chang-Woon Lee studied this question using data on travel times and labor productivity for French cities, they reached several conclusions.[24] They found a robust relationship between the effective labor market size (the size of the available circle, as defined by acceptable travel time) and the productivity of that city. Specifically, when the effective labor market size increased by 10%, productivity (and hence economic output) increased by 1.8%. David T. Hartgen and M. Gregory Fields studied labor market size in the U.S. and found economic gains from reducing traffic congestion of up to 30%, depending on location.[25]

Congestion costs are a major issue for manufacturing and distribution businesses. And understanding the total congestion costs can be challenging. While TTI counts truck congestion, the truck time value reflects only the hourly operating cost of trucks, not the value of trucking services to shippers. Truck congestion affects more than time; congestion wreaks havoc on the reliability of truck pick-up and delivery schedules, a substantial cost that is not included in the *Urban Mobility Report* figures.

Southern California has the busiest ports in the country, with the ports of Los Angeles and Long Beach collectively handling about 40% of the nation's imports and about 24% of the nation's exports.[26] One out of every seven jobs in Southern California depends on this trade, making the effective ground transport of goods extremely important to the region in order to retain its economic competitiveness. Container volume processed by the ports grew by 59% between 2000 and 2010, and is expected to nearly triple by 2030. Much of this ground transport of goods occurs on the region's most congested facilities, including I-5, I-10, I-405, I-710 and SR 60.

Finally, congestion decreases Los Angeles's economic competitiveness. L.A. has been losing jobs for the past 20 years. According to the Census Bureau, the region has fewer jobs today than in 1990 despite gaining 2,000,000 residents.[27] While Southern California's transportation challenges are certainly not the only reason for the economic problems, and fixing the transportation issues will not by itself improve the economy, persistent congestion needs to be addressed. A total of 21 Fortune 500 companies are based in the greater Los Angeles area. If the region wants to keep these important headquarters and attract others, it needs to reduce its congestion problem.[28]

Table 6: Civilian Employment and Labor Force Participation in U.S. Metro Areas

Urban Area	1990 Employment	2010 Employment	1990 Labor Force Participation	2010 Labor Force Participation
New York	3,759,900	8,687,798	73.3%	63.5%
Los Angeles	6,809,043	5,507,175	77.9%	58.8%
Chicago	3,099,100	4,068,433	86.4%	60.6%
Washington D.C.	2,134,400	2,467,218	82.9%	67.7%
Atlanta	1,444,700	2,162,164	81.1%	62.4%
San Francisco	844,300	1,657,843	80.3%	61.2%
Houston	1,634,200	2,361,278	81.6%	63.5%

Source: U.S. Census, Employment Tables—Non-farm Employment, 1990 and 2010, Los Angeles 2020 Commission

C. The Social Costs of Congestion

In many other ways congestion harms Southern Californians beyond those discussed above. It reduces safety, entertainment possibilities, recreation and social life. Gridlocked roads significantly hamper emergency vehicle response time; paramedics may not arrive in time to save a life, or firefighters may be delayed in getting to a fire. Congestion also increases stress. A study conducted by Dr. David Lewis of the International Stress Management Association found some commuters had a higher stress level than fighter pilots entering battle.[29]

After-work congestion causes people to avoid places (restaurants and theaters) that become too much of a hassle to reach. Many commuters leave for work as early as 5:00 AM and leave work as late as 8:00 PM. Parents may miss meal times and their kids' bed times. Congestion shrinks circles of opportunity. Computer dating services report that many subscribers are unwilling to match up with prospects who live more than a certain number of miles away because congestion simply makes it too difficult to develop a relationship.[30] In very large urban regions such as Southern California this can be as few as five miles.

D. The Environmental Costs of Congestion

Oftentimes citizens object to building or widening highways for environmental reasons. While these reasons may be justified, a high level of congestion has many negative effects on the environment. The two compounds in car emissions that harm the environment the most are carbon dioxide (CO_2) and mono-nitrogen oxides (NOx). For both compounds, emissions-released versus speed-traveled is a U-shaped pattern. Cars traveling at free-flow speeds (30–55 miles per hour) release less carbon dioxide than cars traveling in stop-and-go patterns (speeds between 0 and 30 miles per hour).[31] However, typical Southern California congestion reduces traffic speeds in certain areas below 30 miles per hour for up to 12 hours per day, increasing carbon dioxide emissions.

Emissions rates can be reduced the most by decreasing very heavy congestion that keeps vehicle speeds below 30 miles per hour. With increased vehicle fuel efficiency requirements and continued refinement in car engine technology, increasing vehicle free flow speeds to 30 miles per hour or higher will result in the largest reduction in emissions from the light duty vehicle fleet.

E. Live/Work/Play Communities’ Effect on Congestion

One recent trend in development patterns is live/work/play communities. Live/work/play communities are part of a broader movement to encourage residents to live closer to where they work. Some policy makers believe that an increase in live/work play communities will significantly reduce congestion. The reality is much more nuanced.

For example, live/work/play communities are not feasible for some residents. Many people cannot afford to live in many mixed-use communities.[32] Housing in these developments is typically affordable for only part of the population. While affordable housing is offered, it is usually for a very limited number of units. In most communities, including mixed-use, many households have two-income earners. While one earner may live close to his job, it is very unlikely that both will live close to their employment. Residents who choose not to live in mixed-use communities often prioritize quality schools or living in a house with a big yard, over commute times. Often neighborhoods with these features are far from job centers. Further, many folks who live in live/work/play communities do so for the development style of smaller lot sizes and mixed uses—not to be closer to work. Their jobs require long commutes accomplished via the automobile. One of the most famous live/work/play communities, Atlantic Station in Atlanta, has rows of underground parking as most residents own cars and commute to work by car.[33]

Studies find that the effect of new mixed-use developments on overall travel or congestion is minor.[34] Further, mixed-use communities are likely to remain a subset of all residences. Southern California needs a transportation solution for folks who live in central cities, those who live in mixed-use communities and those who live in traditional suburbs.

F. Congestion and Southern California's Future

While the L.A. area dithers on congestion reduction, other major metro areas are taking concrete action. Dallas and Houston have signed on to the Texas Metropolitan Mobility Plan, under which each has selected a lower travel time index than today's to reach by 2030.[35] Seattle, Washington has a strategic blueprint that details how to reduce congestion in the metro area. Regional competitors, including Phoenix and San Francisco, are making substantial investments in their transportation systems to reduce congestion.[36]

In short, major congestion is a significant problem in Southern California, and the economic, social, and environmental costs are substantial. Congestion can harm residents' social life *and* limit economic growth.

Part 3

Current Plans to Reduce Congestion and Improve Mobility

A. Metropolitan Planning Organization Planning Requirements

Several regional and state agencies, led by the Southern California Association of Governments (SCAG), are tasked with developing regional plans to reduce congestion in Southern California.

As a result of federal transportation reforms enacted in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), all metro areas with a population of 50,000 or greater must have a metropolitan planning organization (MPO) charged with distributing federal transportation monies throughout the region. SCAG is Southern California's federally designated planning organization. MPOs must create a long-range transportation plan (LRP), which is a summary of all planned transportation projects over the next 20 years. The MPO takes the projects it plans to complete in the near future and places them in its transportation improvement plan (TIP). Metro areas over 200,000 people are defined as transportation management areas (TMAs). These areas must also have a congestion management system (CMS) that identifies strategies and specific actions to reduce congestion and increase mobility. MPOs also coordinate transportation and air quality planning in metro areas, such as Los Angeles, that are defined as being in "non-attainment" of federal air quality standards.

The state of California has also enacted several specific environmental requirements for planning. First, all plans must incorporate the requirements of Assembly Bill 32—The California Global Warming Solutions Act of 2006. AB 32 requires California to reduce its greenhouse gas emissions to 1990 levels by 2020. AB 32 applies to carbon dioxide, methane, nitrous oxides, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride. MPOs must also incorporate SB 375—The Sustainable Communities and Climate Protection Act of 2008. SB 375 requires the state Air Resources Board to set regional targets for GHG emissions from passenger vehicle usage. Each MPO must prepare a "sustainable communities strategy" as a part of its transportation plan. The Air Resources Board must approve the plan to verify that it meets GHG reduction targets.

The MPO is required to involve other relevant agencies in transportation planning. In Southern California this includes the California Department of Transportation (CalTrans), which partners with SCAG on state and local roads, the six metro counties of Imperial, Los Angeles, Orange, San Bernardino, Riverside and Ventura, and the 191 cities in those counties which partner with SCAG to build county and local infrastructure. (Note: While SCAG includes Imperial County in southeast California in its service area, Imperial County is not considered part of the Los Angeles Region and is not included in this study.) SCAG must also coordinate with transit agencies including Los Angeles Metro, Foothill Transit, Metrolink, the Orange County Transportation Authority, the Riverside Transit Agency, San Bernardino Associated Governments and the Ventura County Transportation Commission.[37]

B. SCAG's Plan 2035 Overview

Traditionally, SCAG has focused on improving mobility. However, in 2000—under pressure from environmental activists—SCAG added livability, prosperity and sustainability to its mobility plans. And for its 2012 plan, as a result of SB 375 that mandates specific reduction in greenhouse gases for cars and light trucks, SCAG had to create a plan that reduces greenhouse gas emissions.[38]

As a result, SCAG developed this 2012 plan differently than previous long-range plans. The agency more closely integrated transportation and land use planning. It developed four plan elements:

- *Development Location* ranging from dispersed growth to focused development,
- *Community/Neighborhood Design* ranging from auto-oriented to walkable,
- *Housing Options/Mix* ranging from single-family subdivisions to multi-family-focused housing, and
- *Transportation Improvements* ranging from roads/highways to transit/non-auto strategies.

After developing the elements, plan makers developed four growth scenarios that structure development in different patterns ranging from moderate density to exceptionally high density.

Scenario 1: This scenario is based on the General Plans prepared by cities and compiled by SCAG, with assistance from local planners, using the Local Sustainability Planning Tool (LSPT). It includes a significant proportion of suburban, auto-oriented development, but also recognizes the recent trend of increased growth in existing urban areas and around transit. New housing is mostly single-family (58%), with an increase in smaller-lot single-family homes, as well as an increase in multi-family homes (42%). The transportation system is based on the package of improvements in the 2008 RTP. While these investments tend to favor automobile infrastructure, they also support new transit lines and other non-auto strategies and improvements.

Scenario 2: This scenario focuses more growth in walkable, mixed-use communities and in existing and planned High-Quality Transit Areas. This scenario would increase investments in transit and non-auto modes as compared to the 2008 RTP. Employment growth is focused in urban centers, around transit. Fewer new homes (29%) are single-family homes, based on the idea that there is a demand for a broader range of housing types, with new housing weighted less toward large-lot single-family homes (2%) and more toward smaller-lot single-family homes (27%) and multi-family condos, townhomes, and apartments (70%).

Scenario 3: This scenario builds on the walkable, mixed-use focus of the growth in Scenario 2 and also aims to improve fiscal and environmental performance by shifting even more of the region's growth into areas that are closer to transit and less auto-centric. Like Scenario 2, this scenario aims to meet demand for a broader range of housing types, with new housing weighted toward smaller-lot single-family homes, townhomes, multi-family condos, and apartments. In terms of percentage, the mix of housing types is very similar to Scenario 2, but the location of the growth within the region shifts more toward transit-rich locations. Also as in Scenario 2, transportation system investments are weighted more toward transit investments, transportation demand management[39] (TDM), and non-auto strategies, which would support the planned move away from more auto-oriented development patterns.

Scenario 4: This scenario maximizes growth in urban and mixed-use configurations in already developed areas and around existing and planned transit investments. To support this shift, transportation system investments are heavily weighted toward transit infrastructure and operational improvements (i.e., higher frequencies and more transit feeder service), as well as improvements to bicycle and pedestrian infrastructure. In order to maximize the transit investments and accommodate population in already developed areas, the vast majority of new housing (96%) is multi-family, while 4% is single-family development.

While SCAG chose a mix of scenarios depending on location, most of its plan seems to focus on Scenarios 2 and 3.

The 2035 Regional Transportation Plan titled Mobility 2035 was adopted in April 2012. This long-range plan includes projects totaling more than $605 billion to improve Southern California's surface transportation system.

The 2035 Regional Transportation Plan devotes funding to the following components. Note: The SCAG plan figures in Tables 7 and 8 reflect nominal dollars estimated for 2010–2035. We have converted these numbers to reflect the years 2015–2040, as shown in parentheses. Full funding details are provided in Table 8:

- **$216.9** billion in maintenance funding. Much of this funding ($139.3 billion) supports transit. The remaining $77.6 supports highways and arterials.
- **$64.2** billion for new highways
- **$55** billion for new transit services including new heavy-rail, light-rail and BRT lines
- **$51.8** billion in new passenger rail services. Most of this funding ($47.7 billion) supports developing high-speed rail between Los Angeles and San Diego, and Los Angeles and the Antelope Valley. A fraction ($4.1 billion) supports new commuter rail.
- **$48.4** billion for goods movement. Most of this funding supports improvements at and related to the Ports of Long Beach and Los Angeles.
- **$22.1** billion for new arterials
- **$7.6** billion for transportation system management
- **$6.7** billion for active transportation (bicycling and walking)
- **$4.5** billion for transportation demand management

Table 7: SCAG Suggested Transportation Investments

Component	Description	Cost
Transit		$55 B
Bus Rapid Transit	New BRT routes, extensions, and/or service enhancements in Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties	$4.6 B
Light Rail Transit	New light rail routes/extensions in Los Angeles and San Bernardino Counties	$16.9 B
Heavy Rail Transit	Heavy rail extension in Los Angeles County	$11.8 B
Bus	New and expanded bus service in Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties	$21.7 B
Commuter and High-Speed Rail		$51.8 B
Commuter Rail	Metrolink extensions in Riverside County and Metrolink systemwide improvements to provide higher speeds	$4.1 B
High-Speed Rail	Improvements to the Los Angeles to San Diego (LOSSAN) Rail Corridor with a goal of providing San Diego-Los Angeles express service in under two hours. Phase I of the California High-Speed Train (HST) project that would provide high-speed service from Los Angeles to the Antelope Valley	$47.7 B

Table 7: SCAG Suggested Transportation Investments

Component	Description	Cost
Active Transportation		$6.7 B
Various Active Transportation Strategies	Increase bikeways from 4,315 miles to 10,122 miles, bring significant amount of sidewalks into compliance with the Americans with Disabilities Act (ADA), safety improvements, and various other strategies	$6.7 B
Transportation Demand Management (TDM)		$4.5 B
Various TDM Strategies	Strategies to incentivize drivers to reduce solo driving including increased carpooling, vanpooling, transit use, telecommuting; redistributing vehicle trips from peak periods to off-peak periods; developing mobility hubs and adding bike racks to buses	$4.5 B
Transportation Systems Management		$7.6 B
Various TSM Strategies	Incident management, ramp metering, traffic signal synchronization, data collection, smart transit cards	$7.6 B
Highways		$64.2 B
Mixed Flow	Interchange improvements to and closures of critical gaps in the highway network to provide access to all parts of the region	$16.0 B
High Occupancy Vehicle, High Occupancy Toll	Closure of gaps in the high-occupancy vehicle (HOV) lane network and the addition of freeway-to-freeway direct HOV connectors to complete Southern California's HOV network. A connected network of Express/HOT lanes	$20.9 B
Toll Facilities	Closure of critical gaps in the highway network to provide access to all parts of the region	$27.3 B
Arterials		$22.1 B
Various Arterial Improvements	Spot widenings, signal prioritization, driveway consolidations and relocations, grade separations at high-volume intersections, new bicycle lanes, and other design features such as lighting, landscaping, and modified roadway, parking, and sidewalk widths	$22.1 B
Goods Movement		$48.4 B
Various Goods Movement Strategies	Port access improvements, freight rail enhancements, grade separations, truck mobility improvements, intermodal facilities, and emission-reduction strategies	$48.4 B
Operations and Maintenance		$216.9 B
Transit	Operations and maintenance to preserve our multimodal system in a good state of repair	$139.3 B
Highways		$56.7 B
Arterials		$20.9 B
Debt Service		$45.1 B
Miscellaneous Items/Rounding		$2.7 B
Total		**$605.6B**

Source: Southern California Association of Governments 2012 Long Range Plan

Table 8: SCAG Planned Additional Revenue Sources

Revenue Source	Description	Amount
Bonds Proceeds from Local Sales Taxes	Issuance of debt against sales tax revenues	$25.6 B
State and Federal Gas Excise Tax Adjustments	Additional gasoline tax imposed at the federal and state levels from 2017-2024	$16.9 B
Mileage-Based User Fees	Mileage-based user fees (MBUF) to replace gas taxes in 2025	$110.3 B
Highway Tolls	Toll revenues generated from SR 710 North Extension, I-710 South Freight Corridor, East-west Freight Corridor, segment of the High Desert Corridor, and Regional Express/HOT Lane Network	$22.3 B
Private Equity Participation	Private equity share	$2.7 B
Freight Fee/National Freight Program	Expected federal funding for freight	$4.2 B
E-Commerce Tax	Existing revenues which are not being collected	$3.1 B
Interest Earnings	Interest earnings from toll bond proceeds	$0.2 B
State Bond Proceeds	State general obligation bonds	$33.0 B
Value Capture Strategies	Formation of special districts using tax increment financing (TIFs)	$1.2 B
Total		**$220 B**
Total Converted to 2015–2040 nominal dollars		**$254 B**

Source: Southern California Association of Governments 2012 Long Range Plan

C. Plan Analysis

While the 2012 plan includes many important projects, the plan fails to solve some of the region's biggest problems, due in large part to mandates outside SCAG's control. SCAG did a great job given the limitations in California law. SB 375 takes much of the decision-making power out of the hands of professionally trained engineers and planners. As a result the 2012 plan is fragmented.

This $606 billion plan should more effectively improve mobility, defined as reducing congestion from current levels. Since the plan must take a certain approach to reducing GHGs, the plan fails to increase mobility. There are other ways to reduce greenhouse gases without impairing mobility. These alternatives are discussed later in this chapter.

D. Mobility

The plan spends only $64.2 billion (12.2%) of its total budget on adding highway capacity (interchanges, express toll lanes and other toll facilities). Based on current levels of congestion that is unlikely to significantly reduce congestion. The plan spends more than twice as much on transit services as it devotes to highway capacity, much of it on construction and maintenance of new rail lines. The $48.4 billion the plan spends on port access, freight rail enhancement and intermodal facilities will provide needed improvements to the freight transportation system. The $7.6 billion in revenue devoted to intelligent transportation systems (ITS), is a good use of resources. ITS systems have the best benefit-cost ratios of any transportation improvement.

The plan includes $51.8 billion in new railway spending. A fraction—$4.1 billion—is new commuter rail while the remainder—$47.7 billion—is dedicated to building high-speed rail between Los Angeles and San Diego and Los Angeles and the Antelope Valley. Both types of railway projects have very large construction costs. Commuter rail typically costs at least three times as much as more direct bus service.[40] SCAG and the transit agencies should instead use the money on bus rapid transit and express bus services. California's high-speed rail (HSR) line is in limbo barring the resolution of several court cases. Most transportation experts believe the entire line is unlikely to be built in the near future. All of this $51.8 billion could be used on higher priority projects.

The 2012 plan also includes $55.0 billion for new transit. Unfortunately the plan devotes only $26.2 billion to bus service (BRT, express bus, limited-stop bus, local bus) while spending $28.7 billion on rail service (light rail, heavy rail). Yet bus riders outnumber rail riders in Southern California 8 to 1.[41] Further, the area's urban spatial structure of moderate density and multiple job centers does not allow fixed-rail service to work effectively. Southern California could create a world-class bus-based transit system if it devoted its rail expenditures to bus services.

The 2012 plan spends $6.7 billion on active transportation. Active transportation includes biking, walking and other non-motorized transportation. We understand the importance of biking and walking to Southern Californians, including adding bikeways and bringing sidewalks into compliance. Assuming these projects support transportation mobility, these funds are an appropriate use of transportation monies. We also support narrowing lane-widths, where appropriate, from 12 feet to 10.5 feet to create bike lanes.

The 2012 plan devotes $4.5 billion to transportation demand management (TDM). SCAG's TDM plan includes increasing carpooling, vanpooling, transit, active transportation and telecommuting, as well as redistributing vehicle trips from peak to off-peak hours and including bike racks on transit vehicles. TDM is an excellent strategy, and a smart use of limited funds. We also encourage the private sector to take on the responsibility of adding bike racks and engaging in promotions and advertising.

The 2012 plan devotes $139.6 billion to transit operations and maintenance. This is the largest component of the plan. While maintenance is vital, by building several new rail lines Southern California is forcing itself to spend more on maintenance than it would if it added new bus lines. Both bus and rail lines have similar costs to maintain the vehicles. But while buses make use of roadway paid for by operators of cars and trucks, rail operators must shoulder their entire infrastructure costs themselves. And rail lines need to maintain their power systems; heavy-rail lines need to maintain their third rail electrical systems, while light-rail lines need to maintain their catenary system.

Table 9 below details all of SCAG's performance indicators. SCAG develops a number of performance measures but only the Mobility and Accessibility metrics are concerned with reducing congestion and improving mobility. Further, only the Investment Effectiveness determines whether the projects are an efficient use of taxpayer funds.

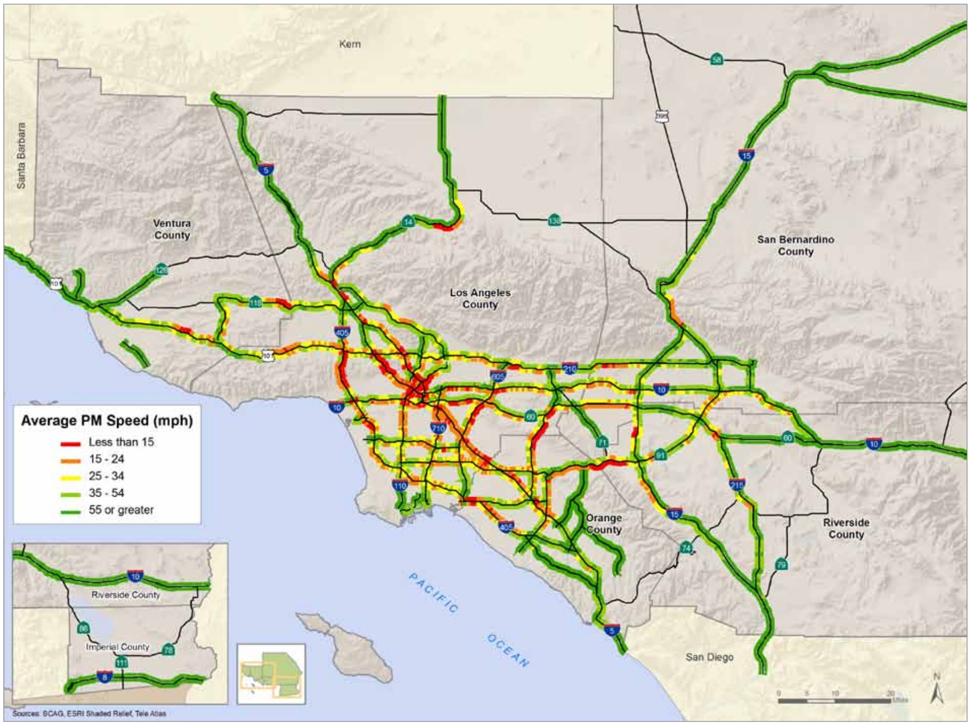
Table 9: SCAG Performance Improvements

Outcomes	Performance Measure/Indicator	Definition	Performance Target	Data Source Used
Location Efficiency	Share of growth in High-Quality Transit Areas (HQTAs)	Share of the region's growth in households and employment in HQTAs	Improvement over No Project Baseline	Census
	Land consumption	Additional land needed for development that has not previously been developed or otherwise impacted, including agricultural land, forest land, desert land, and other virgin sites	Improvement over No Project Baseline	Rapid Fire Model
	Average distance for work or non-work trips	The average distance traveled for work or non-work trips separately	Improvement over No Project Baseline	Travel Demand Model
	Percent of work trips shorter than 3 miles	The share of total work trips shorter than 3 miles	Improvement over No Project Baseline	Travel Demand Model
	Work trip length distribution	The statistical distribution of work trip length in the region	Improvement over No Project Baseline	Travel Demand Model
Mobility and Accessibility	Person delay per capita	Delay per capita can be used as a supplemental measure to account for population growth impacts on delay	Improvement over No Project Baseline	Travel Demand Model
	Person delay by facility type (mixed flow, HOV, arterials)	Delay—excess travel time resulting from the difference between a reference speed and actual speed	Improvement over No Project Baseline	Travel Demand Model
	Truck Delay by facility type (highway, arterials)	Delay—excess travel time resulting from the difference between a reference speed and an actual speed	Improvement over No Project Baseline	Travel Demand Model
	Travel time distribution for transit, SOV, HOV for work and non-work trips	Travel time distribution for transit, SOV, HOV for work and non-work trips	Improvement over No Project Baseline	Travel Demand Model
Safety and Health	Collision/accident rates by severity by mode	Accident rates per million vehicle-miles by mode (all, bicycle/pedestrian, and fatality/killed)	Improvement over Base Year	CHP Accident Data Base, Travel Demand Model Mode Split Outputs
	Criteria pollutants emissions	CO, NOx, $PM_{2.5}$, PM_{10}, and VOC	Meet Transportation Conformity requirements	Travel Demand Model/ARB EMFAC Model
Environmental Quality	Criteria pollutant and greenhouse gas emissions	CO, NOx, $PM_{2.5}$, PM_{10}, and VOC Per capita greenhouse gas emissions (CO_2)	Meet Transportation Conformity requirements and SB 375 per capita GHG-reduction targets	Travel Demand Model/ARB EMFAC Model
Economic Well-being	Additional jobs supported by improving competitiveness	Number of jobs added to the economy as a result of improved transportations conditions which make the region more competitive	Improvement over No Project Baseline	Regional Economic Model REMI
	Additional jobs supported by transportation investment	Total number of jobs supported in the economy as a result of transportation expenditures	Improvement over No Project Baseline	Regional Economic Model REMI
	Net contribution to gross regional product	Gross regional product due to transportation investments and increased competitiveness	Improvement over No Project Baseline	Regional Economic Model REMI
Investment Effectiveness	Benefit/cost ratio	Ratio of monetized user and societal benefits to the agency transportation costs	Greater than 1.0	California Benefit/Cost Model
System Sustainability	Cost per capita to preserve multimodal system to current and state of good repair conditions	Annual costs per capita required to preserve the multimodal system to current conditions	Improvement over Base Year	Estimated using SHOPP Plan and recent California Transportation Commission 10-Year Needs Assessment

Source: Adapted from SCAG Table 5.1

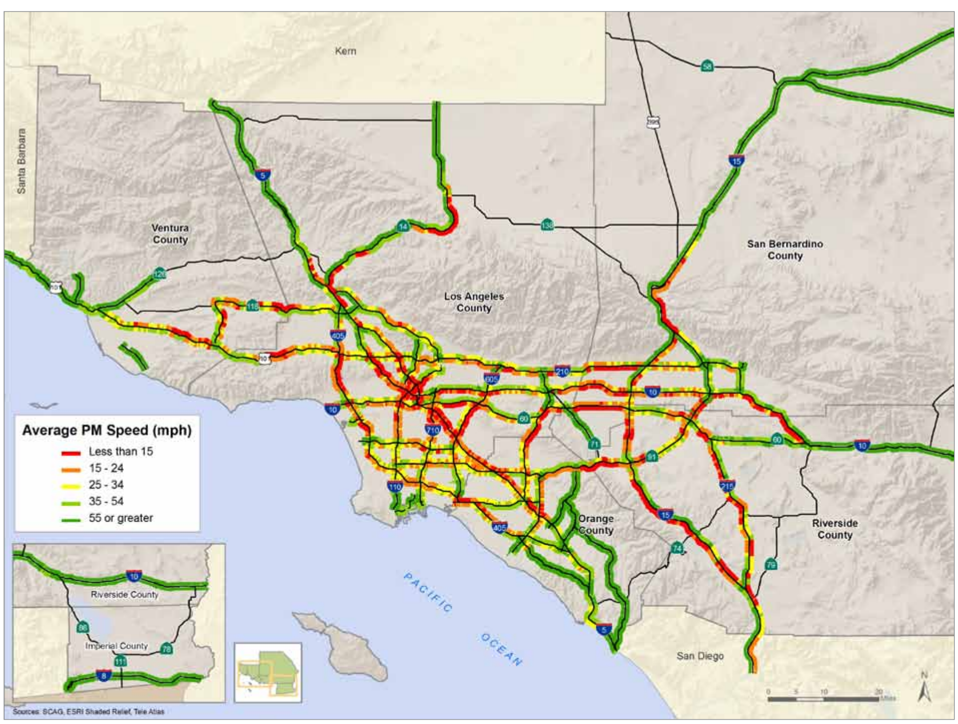
For the Mobility measures, SCAG provides three figures we included below: a 2008 figure, a 2035 figure if no improvements are made, and a 2035 figure if plan improvements are made. For most categories, the congestion in 2035 with the improvements is the same as or worse than in 2008. In other words, the region is preparing to spend $606 billion over the next 25 years to provide a system with mobility that is no better than the status quo.

Figure 5: 2008 Southern California Expressway Speeds



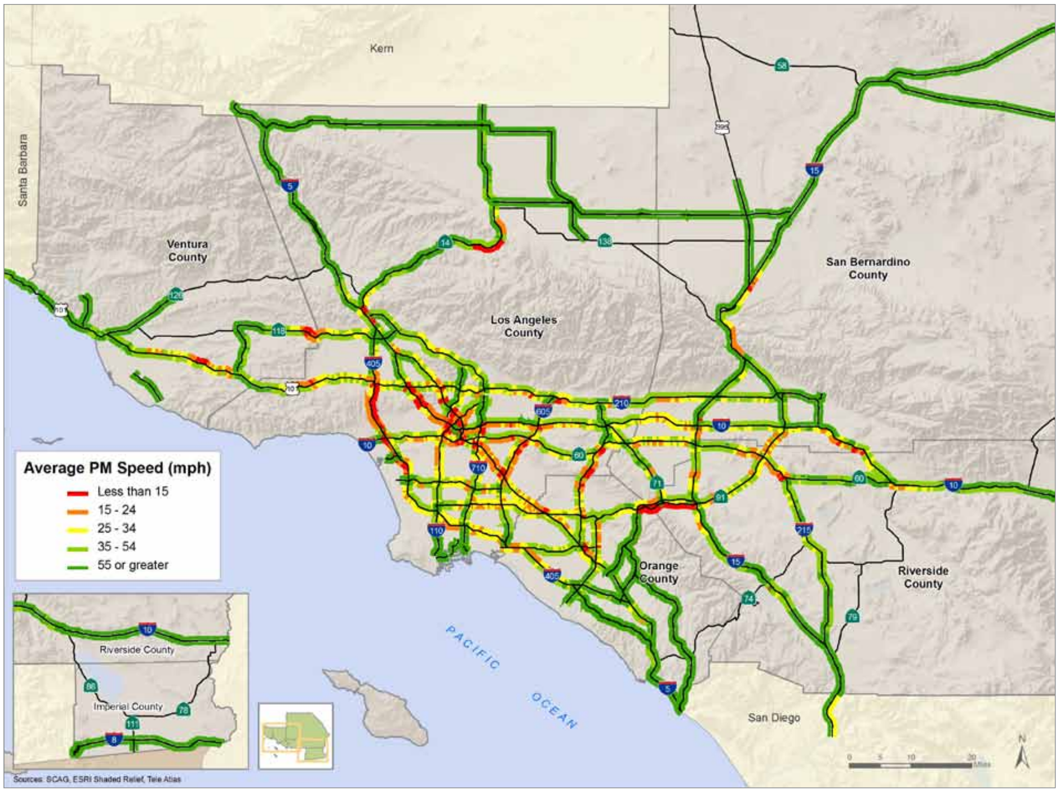
Source: SCAG's 2012 Long Range Plan, Highways and Arterials Appendix

Figure 6: 2035 Southern California Expressway Speeds with No Improvements



Source: SCAG's 2012 Long Range Plan, Highways and Arterials Appendix

Figure 7: 2035 Southern California Expressway Speeds with Planned Improvements



Source: SCAG's 2012 Long Range Plan, Highways and Arterials Appendix

Specifically, as shown in Table 10 below, person hours of delay are about the same for freeway/expressway and arterial and slightly better for HOV and regional average. Heavy-duty truck hours of delay are actually significantly worse for expressways and slightly worse for arterial truck hours of delay.

Table 10: Delay by Facility Type

Type of Road	Trend between 2008 and 2035
Expressway	About the Same
High Occupancy Vehicle Lane	Slight Improvement
Arterial	About the Same
Regional Average	Slight Improvement
Truck Expressway	Significant Deterioration
Truck Arterial	Slight Deterioration

Source: Southern California Association of Governments 2012 Long Range Plan, http://rtpscs.scag.ca.gov/Pages/2012-2035-RTP-SCS.aspx

Many of the worst expressway sections show no improvement between today and 2035 with the plan implemented. Table 11 below measures all sections of Southern California's expressways with average travel speeds below 15 miles per hour.[42] There are many other sections where speeds are below free-flow conditions; the sections below are the worst of a poorly performing system. A total of 36 segments operate below 15 miles per hour today, in 2035 with improvements, or in most cases both today and in 2035 with improvements. Thirty-three of the segments are congested today and 30 remain congested in 2035 if the plan's improvements are made. Four sections that do not operate below 15 miles per hour today will do so in 2035 even with all the improvements in the plan. While there is a minor improvement overall, $606 billion should enable Southern California to get a much larger increase in mobility.

Table 11: Severely Congested Expressway Segments
(Average speeds less than 15 miles per hour during afternoon rush hours)

Segment	County	In 2012	In 2035 with Plan implemented
I-5N between SR 261 and SR 91	Orange	Yes	Yes
I-5N between SR 91 and I-605	Los Angeles, Orange	Yes	Yes
I-5N between I-605 and I-10E	Los Angeles	Yes	Yes
I-5N between I-10E and SR 134	Los Angeles	Yes	Yes
I-5N between SR 134 and I-405 north junction	Los Angeles	Yes	No
I-5N between I-405 north junction and SR 14	Los Angeles	Yes	Yes
I-5S between SR 134 and I-10E	Los Angeles	Yes	Yes
I-5S between I-710 and I-605	Los Angeles	Yes	Yes
I-10E between I-405 and I-5	Los Angeles	Yes	Yes
I-10E between I-5 and I-605	Los Angeles	Yes	Yes
I-10E between SR 210 and SR 60	Riverside, San Bernardino	No	Yes
I-15N between SR 60 and I-210	Riverside, San Bernardino	Yes	Yes
I-15N between SR 138 and SR 18	San Bernardino	No	Yes
I-15N between I-215 and SR 138	San Bernardino	Yes	No
I-15S between SR 60 and SR 91	Riverside, San Bernardino	Yes	No
I-105E between SR I-710 and I-605	Los Angeles	Yes	No
I-110/SR 110N between I-10 and I-5	Los Angeles	Yes	Yes
I-210E between SR 134 and I-605	Los Angeles	No	Yes
I-210E between I-605 and I-57	Los Angeles	Yes	Yes
I-215S between SR 91 and SR 60	Riverside	Yes	Yes
I-405N between SR 55 and SR 22	Orange	Yes	No
I-405N between I-10 and US 101	Los Angeles	Yes	Yes
I-405S between I-10 and I-105	Los Angeles	Yes	Yes
I-405N between SR 22 and I-605	Los Angeles, Orange	Yes	No
I-405S between I-605 and SR 22	Los Angeles, Orange	Yes	No
I-605N between I-5 and SR 60	Los Angeles	Yes	Yes
I-710N between I-5 and I-10	Los Angeles	Yes	Yes
US 101N between SR 110 and SR 170	Los Angeles	Yes	Yes
US 101S between SR 170 and SR 110	Los Angeles	Yes	Yes
US 101N between I-405 and SR 23	Los Angeles, Ventura	Yes	Yes
US 101N between SR 23 and SR 126	Ventura	Yes	Yes
SR 14W between Sierra Highway exit 26 and Sierra Highway exit 30	Los Angeles	Yes	Yes
SR 55N between I-5 and SR 91	Orange	Yes	Yes
SR 57N between SR 91 and SR 60E	Orange, Los Angeles	Yes	Yes
SR 91E between SR 241 and I-15	Orange, Riverside	Yes	Yes
SR 118E between SR 23 and SR 27	Los Angeles, Ventura	No	Yes
SR 118W between SR 27 and SR 23	Los Angeles, Ventura	Yes	Yes

Source: SCAG's 2012 Long Range Plan

E. Livability, Prosperity and Sustainability

The Department of Transportation defines livability as "…tying the quality of location of transportation facilities to broader opportunities such as access to good jobs, affordable housing, quality schools, and safer streets and roads."[43] Yet by reducing mobility, the plan reduces livability. Many of the residents who live in Riverside and San Bernardino County, where most of the affordable housing is located, work across the mountains in Los Angeles and Orange Counties, where most of the employment is located. Yet most of these commuters have just one congested expressway, a few congested arterials and several bus routes that use the congested roadways to make this commute; these limitations result in a longer trip that adds stress and reduces commuters' amount of leisure time. Many of the residents who place a priority on quality schools and safer streets live in suburban areas with long commutes to job centers. Even residents living in growing downtown Los Angeles often commute many miles to work because of the numerous business centers in the region. Since almost 90% of metro areas residents drive or take a bus to work, allowing congestion to worsen will make the majority of residents' lives worse, not better.

Prosperity typically means that residents have a high enough income to maintain a good quality of life. Yet California seems to be worsening in this regard. The Southern California region has lost jobs between 1990 and 2010. As we discussed in Part 2, severe congestion limits residents' circles of opportunity decreasing their job possibilities. Worse, California is one of the most expensive places to live in the country, with the fourth highest tax burden of any state.[44] While the state may provide more services than competitors, it is little comfort for the unemployed and underemployed. California has the highest percentage of underemployed residents in the country.[45]

Many of the components of the plan involve sustainability. Yet some of the back-to-the-city-center suggestions are not truly sustainable. While some people may only be concerned with environmental sustainability, sustainability is a three-legged stool with economic factors, environmental factors and equity issues receiving equal weight.[46] Economic sustainability tries to promote economic vitality. Environmental or ecological sustainability incorporates the natural system processes. The equity component in sustainability deals with social welfare.

One typical suggestion to improve sustainability is building more mixed-use developments closer to downtown. But as discussed in the previous chapter, while this can increase downtown's population, living in these developments often requires a six-figure salary and most offer very few low-income units; most of the commercial jobs located in mixed-use developments offer primarily low-wage retail positions. Often, the residents of mixed-use developments work somewhere else and the workers in the development live somewhere else.[47] As a result there is a lot of single-occupant car commuting. This commuting scenario is not what most environmentalists want.

Another common way to improve sustainability is to locate a new development targeting upper-middle class residents near a rail line. Often this development either replaces low-income housing or raises taxes so significantly that low-income folks can no longer afford to live in the neighborhood. These low-income families are often displaced to the suburbs, far from where they work. While the new residents of the mixed-use developments use transit more than when they lived in the suburbs, the displaced residents who were dependent on transit in the city, face far more limited transit services in the suburbs.[48] As a result, the net use of transit decreases. This situation is not ecologically sustainable nor is it sustainable from an equity standpoint. It is also unlikely to be economically sustainable. Sustainability is an important goal, but many of the practices suggested in the region's transportation plan are unlikely to improve total sustainability.

There are better ways for Southern California to improve livability, prosperity and sustainability. If the region is looking to improve livability, it should attempt to bring more high-paying jobs to Riverside and San Bernardino Counties. California could also improve its public schools, ranked in the bottom 10 of all states in most education surveys.[49] For prosperity the state should try to lower its overall tax burden. It also needs to find ways to increase and diversify its employment base. Clean manufacturing is currently shunned by the state. Yet it appears to be a good match with the unemployed and underemployed living in Riverside and San Bernardino Counties. In this way, the region needs to look holistically for sustainability.

F. Climate Change

Reducing greenhouse gases, the main drivers of climate change, is an achievable and important goal for Southern Californians and California's numerous tourist attractions, including national parks and picturesque beaches. By forcing a certain type of development, SB 375 will not reduce GHGs any more than traditional development with the correct pricing of infrastructure.[50]

Further, substantial progress has already been made in reducing California's GHGs. The state reduced its carbon dioxide emissions by 30.9 million metric tons or 8.2% between 2000 and 2011.[51] Today's vehicle fleet generates 98% fewer hydrocarbons, 96% less carbon monoxide and 90% less nitrous oxides emission than cars 30 years ago.[52] The number of days of "unhealthy air" in the region has decreased 74% in just 12 years.[53] As a result, California's GHGs have decreased significantly despite an absolute increase in vehicles and miles traveled.

Current laws will reduce vehicle emissions even further. The federal government recently mandated a 54.5 miles per gallon standard for the new vehicle fleet by 2025.[54] Based on current estimates of vehicle-miles traveled, greenhouse gas emissions will be 19% lower in 2030 than in 2005.[55]

Fortunately, SCAG was able to develop several market-based approaches to reducing congestion. Demand management is an important component of the plan. Priced lanes including High Occupancy Toll (HOT) and express toll lanes that provide uncongested travel are an important part of the solution as well.

G. Funding Issues

Federal law dictates that each MPO should create a long-range plan that is financially realistic, balancing capital and operating costs with reasonable revenue expectations. The region's $606 billion plan will require approximately $254 billion in new resources as current taxes and user fees are forecast to raise only $352 million. Finding an additional $254 billion may not be realistic. While SCAG provides a list of potential sources, none of those revenues is guaranteed.

Part of the funding problem is the gap in funding for the planned high-speed rail system. The line from Los Angeles to San Francisco alone will cost $70 billion to build, and California only has $10 billion. And part of that $10 billion includes a state match that the state may not be able to produce. HSR backers are counting on using cap and trade funds, finding private financing and securing more federal funds. Use of each of these revenue sources is problematic. Cap and trade funds are supposed to be used on projects that substantially reduce greenhouse gases, but there is very little greenhouse gas reduction from high-speed rail, once the huge carbon footprint of its construction is taken into account.[56] Despite repeated requests, no private party has stepped forward to fund the high-speed rail project; further, as long as Republicans control Congress, through at least through January 2017, the project is unlikely to receive any further federal funding.

Due to the region's large population, it receives a significant amount of funding ($84.3 billion) from the federal government. Future federal funding is uncertain. The federal gas tax has not been raised in 20 years and maintaining current funding has been a major challenge.

H. Why the Historical Road-Building Approach Will Not Work

The region's plans (particularly scenarios 3 and 4) represent one extreme approach to increasing mobility—attempting to drastically curtail the use of autos, trucks, and buses by not expanding expressways and further densifying land use. Another extreme approach that is just as problematic is adding extensive non-priced highway capacity throughout the region. Non-priced capacity improvements alone in populated regions cannot solve the problem of urban congestion. Experience suggests that new general lane capacity quickly fills up in growing metro areas, with previous congestion levels reasserting themselves five to 10 years after the non-priced capacity improvement project is completed. This phenomenon of highways becoming congested soon after they are widened is labeled "induced demand" and occurs for two reasons.[57]

First, most metro areas are growing. While the new or expanded highway may have sufficient capacity for residents at the time it is completed, it does not have extra room for growth. A current example is the $1.1 billion project that added a single HOV lane (one-way) on I-405 through the Sepulveda Pass. Despite the added lane, Caltrans expects the southbound segment from US 101 to I-10 to be the most congested in the region as soon as the end of 2015.[58] Most large-scale roadway expansions provide congestion relief in the short-term and possibly the medium-term (depending on how fast the region grows), but become congested again thereafter.

Second, residents often have unmet travel needs. Severe congestion may discourage consumers from eating at a restaurant or watching a Los Angeles Dodgers game at the stadium. But when congestion is reduced, these residents will make these trips. Infrastructure improvements that induce residents to make additional trips are good from an economic development perspective. However, they undermine congestion relief.

Adding non-priced lanes is not realistic for other reasons: large-scale construction projects are politically challenging because they require the acquisition of extensive rights of way via eminent domain proceedings and displace significant businesses and residences. Moreover, the costs of such undertakings are very high, generally exceeding available funding.

As such, adding large amounts of unpriced lanes is not the best solution to any urban area's transportation problems. While SCAG includes some additional general lane capacity, our plan includes none. General purpose widenings should be discouraged in the future.

1. Our Proposed Southern California Mobility Strategy

Since neither of the extremes is an effective long-term way to increase mobility, we have developed a middle-ground that effectively increases mobility without increasing induced demand, adding greenhouse gases to the atmosphere or creating other land-use and environmental concerns.

First, the plan outlined in this report will reduce congestion on expressways by establishing a region-wide network of express lanes—dynamically priced, all-electronically tolled lanes that offer drivers fast, reliable travel times if they choose to pay for them. Many of these lanes will be new additions, as our plan does not convert existing general purpose lanes to express toll lanes, though it would convert existing HOV lanes to express toll lanes, as a cost-effective way to build out the network.

Second, our plan expands some inadequate expressway interchanges and rebuilds several functionally obsolete and structurally deficient interchanges. These investments will unclog some of the region's (and the country's) worst expressway bottlenecks.

Third, our plan proposes filling in a number of key missing links in the overall expressway network, including the gap in the I-710 expressway in South Pasadena. All six of these projects would be financed in part via toll revenues, and all the new lanes would be electronically tolled.

Fourth, our plan will reduce congestion on Southern California's arterial network—a vital complement to the expressway system—by adding dynamically priced, all-electronically tolled underpasses at busy intersections. These underpasses will allow buses and motorists to bypass signalized intersections, offering them faster and more-reliable travel times for those who choose to pay for them. These underpasses will also be new additions. The plan would not force anyone to use these underpasses. Arterials that have been improved in this way are known as "managed arterials" (analogous to managed lanes on expressways).

Fifth, our plan advocates better operational management that makes use of intelligent transportation systems (ITS). These improvements build on our previous work by making the most efficient use of the area's roadway system. Such improvements will also lessen non-recurrent congestion by reducing accidents and ensuring those that do occur are cleared from the road in a timely manner.

Sixth, this network of express toll lanes and managed arterials, combined with operational management using ITS, will enable a high-quality, region-wide transit system. Such a system will consist of existing local bus and limited-stop bus complemented by bus rapid transit running on managed arterials and express bus running in express toll lanes on expressways. This kind of transit is vastly less expensive than heavy rail, light rail and commuter rail, because it uses infrastructure paid for largely by cars and trucks. Because of this much lower cost, the region will be able to build a comprehensive transit network many years sooner.

2. Roadway Cost Estimation Tool

In the following four parts we used the Federal Highway Administration's Highway Economic Requirements System (HERS) cost data for different types of construction. For the purposes of this study, Southern California comprises three sub-regions: Los Angeles-Orange County, which is considered a "major urbanized area," and Riverside-San Bernardino and Ventura, which are considered large, urbanized areas. To err on the conservative side we used the Los Angeles-Orange County figures for the entire region. We developed generic cost estimates for each of the components and added the costs together to create the proposed network. Details on the costs of each specific project and component are available in the appendices.

Unit costs for each of these components were developed using 2014 dollars. Any adjustments for inflation used a 2.9% annual inflation rate, the same rate SCAG uses.

Table 12: Cost per Roadway Component per Lane-Mile

Component (per lane mile)	Cost
New surface arterial lane	$12.7M
New expressway lane	$17.1M
New express lane	$18.0M
New truck express lane	$27.0M
New express lane via conversion from HOV lane	$8.4M
Right of way	$10.4M
New elevated lane	$18.8/$24.4M*
Flyover quadrant	$90M
Ramp from arterial to elevated roadway	$10M
Managed arterial overpass (standard)	$42M
Managed arterial overpass and underpass (dual)	$78M

*Exact cost depends on type of facility. Two-lane facilities are $24.4 million per lane-mile; four-lane or more facilities are $18.8 per lane-mile

Part 4

Alleviating Major Interchange Bottlenecks

The first major aspect of increasing mobility and reducing congestion is eliminating major bottlenecks. An expressway bottleneck is a specific point on the expressway network where traffic gets clogged due to physical limitations of the system. The worst bottlenecks tend to occur at expressway-expressway interchanges where on-ramps carry large numbers of vehicles onto an expressway without providing sufficient merging space or dedicated lanes. Some bottlenecks occur where on- and off-ramps are too close together, resulting in excessive weaving as cars cross each other's paths getting on and off in too short a distance. Other bottlenecks occur where the number of lanes suddenly decreases by one and traffic has to squeeze into the remaining lanes.

Expressways are not the only roads with bottlenecks. Arterials—surface streets that are designed to move cars, trucks and buses long distances—also have bottlenecks. This chapter will focus on arterial bottlenecks at expressway interchanges. Part 6 will focus on bottlenecks where one arterial crosses another arterial.

Fixing these minor bottlenecks is part of the ongoing work program of a state department of transportation (DOT) as it modernizes the roadway system over the years. But even though they are called "minor," these projects are still costly, so they may not get funded for many years, even though the need is obvious.

Bottleneck interchanges of this sort are being redesigned and rebuilt nationwide, as money can be found to pay for these major projects. A review of recent projects to reconstruct bottleneck interchanges around the country found that project costs range from about $50 million to about $1.2 billion.[59] These costs can also be far higher, depending on factors such as local geology, topography, engineering, and availability of financing.

Table 13: Recent Interchange Bottleneck Reconstruction Projects

Interchange	Project Description	Costs	Lane-Miles Added	Construction Dates
San Francisco SR 92/I-880	Replace 2 cloverleaf ramps with direct access ramps	$245M	0	10/07-10/11
Washington D.C. I-495/I-95S	Rebuild interchange ramps Including express lanes	$676M	0	10/03-07/07
Houston I-610/I-10W	Reconstruction of interchange and bridges	$262.5M	0	10/04-01/10
South Florida I-595 between I-75 and I-95	Build three new lanes, rebuild bridges, rebuild entry/exit ramps	$1.2B	41	02/10-06/14

Source: California Department of Transportation, Florida Department of Transportation, Texas Department of Transportation and Virginia Department of Transportation.

Since most of the Los Angeles region's worst bottlenecks are expressway-expressway and expressway-arterial, we have focused on addressing these failing interchanges.

A. Expressway-Expressway Bottlenecks

On expressways, Southern California has a large number of problematic cloverleaf expressway-expressway ramps whose geometric characteristics reduce the throughput of all vehicles, particularly trucks. These ramps, many 50 years old, need to be replaced. Due to costs and political challenges, our recommendations range from small fixes to partial reconstructions. Full reconstructions would cost more than $1 billion per interchange and would only reduce congestion around the interchange, not on the expressway as a whole. We focused on small to moderate projects that significantly reduce congestion while not using all of the region's resources on expressway interchanges. In order to determine the most-congested interchanges we used data from several sources. First, we used Texas A&M Transportation Institute's congested corridor report. The report, using 2010 data, takes a comprehensive look at the worst places for congestion in the United States.[60] We supplement this report with more recent 2014 data from Caltrans.

Many other improvements, detailed in later sections, remove many bottlenecks by creating redundancy or alternate connections in the expressway and arterial networks. However, 10 of the region's expressway-expressway bottlenecks are so congested that we recommend spending resources on the bottleneck. The 10 major bottlenecks are detailed below.

Costs were determined using the tables in the previous section. The figures were adjusted as needed, based on the width of the ramp lanes and merge lanes required. Each intersection, the movements affected, and the costs to rebuild the interchange are in the following table. Full cost details for each component are listed in Appendix A, Table A1.

Table 14: Most Congested Interchanges

Ranking	Interchange	Movements Affected	Cost
1.	I-10/I-110	I-10W to I-110S, I-10W to I-110N, I-10E to I-110S, I-10E to I-110N, I-110N to I-10W, I-110N to I-10E, I-110S to I-10E	$397.2M
2.	I-10/I-405	All and add 1 new lane on I-10 in each direction between I-405 and SR 1S	$506.4M
3.	I-10/I-5	I-5 to I-10W, I-10W merge with I-5N, I-5S to SR 60E, I-10W to I-5N, I-10E to I-5S, SR 60 to I-5N and on I-5 add 1 new lane in each direction between I-10W and I-10E and on I-10 US 101 Connector between I-5 and US 101	$396M
4.	US 101/SR 110	SR 110N to US 101N, US 101S to SR 110S	$118.6M
5.	I-405/US 101	I-405N to US 101N, US 101S to I-405S	$150M
6.	I-5/I-605	I-5N to I-605N, I-5S to I-605S, I-5N to I-605N, I-605N to I-5N	$334.2M
7.	I-5/I-710	I-710N to I-5N, I-5S to I-710S	$120M
8.	I-10/I-605	I-10W to I-605S, I-10E to I-605N, I-605N to I-10W, I-605N to I-10E,	$302.2M
9.	I-605/SR 60	I-605N to SR 60W, I-605N to SR 60E, I605S to SR 60W, I-605S to SR 60E, SR 60W to I-605S, SR 60W to I-605N, SR 60E to I-605S	$400M
10.	I-5/CA 55	I-5N to SR 55N, I-5N to SR 55S, I-5S to SR 55S, SR55N to I-5N, SR55S to I-5S,	$349.2M
Total			**$3.07B**

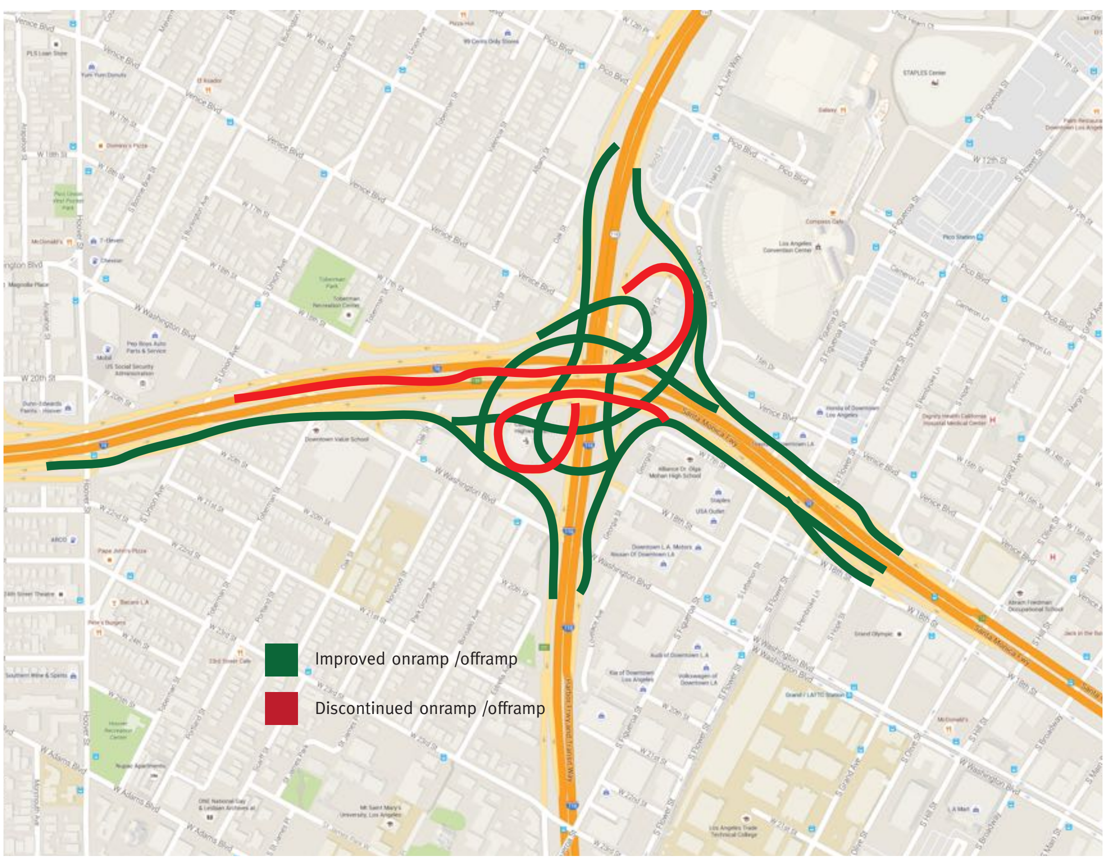
The following section describes each interchange bottleneck and examines the proposed changes. Complete details are available in Appendix A.

1. I-10 at I-110

The I-10 at I-110 interchange is located southwest of downtown Los Angeles in the west-central part of the region. I-10 has average daily traffic volumes (AADT) over 300,000 while I-110 has an AADT exceeding 270,000.

Fixing this interchange requires several steps. First, the ramp from I-110 north to I-10 west needs to be rebuilt with two lanes instead of one and the loop eliminated. Second, the ramp from I-110 north to I-10 east needs to be widened to two lanes. The ramp from I-110 south to I-10 east needs to be widened to two lanes and the loop eliminated. The ramp from I-10 east to I-110 south needs to be widened to two lanes and the ramp from I-10 east to I-110 north needs to be widened to three lanes with the terminus moved from the left side of the road to the right side. Both ramps from I-10 west to I-110 north and I-110 south need to be widened to two lanes.

Figure 8: Interchange Design: I-10 and I-110

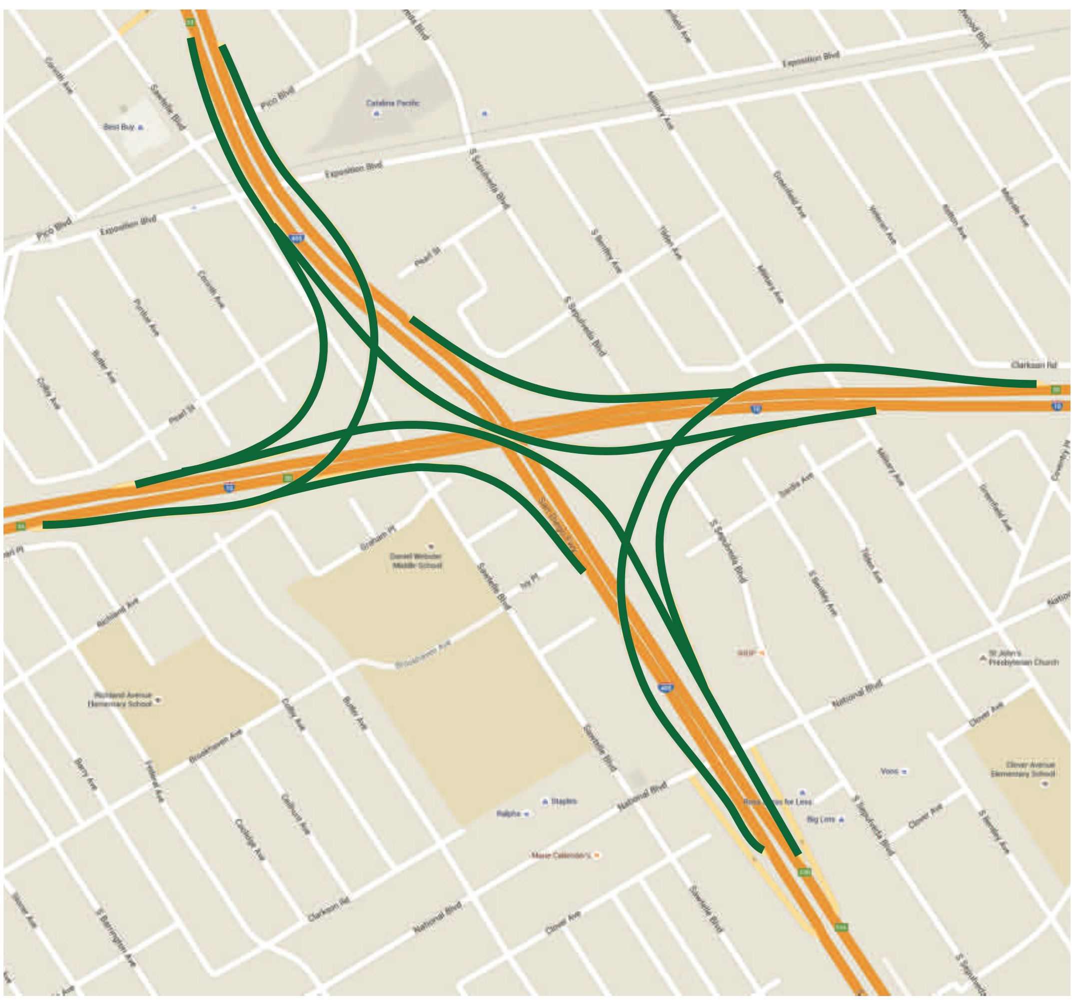


2. I-10 at I-405

The I-10 at I-405 interchange is located west of downtown in the west central part of the region between Culver City and Santa Monica. I-10 has average traffic volumes (AADT) of over 220,000 while I-405 has AADTs of over 310,000.

Similar to the first project, modernizing this interchange is a multi-step process. First, widen the ramp from I-10 west to I-405 north to three lanes and widen the ramp from I-10 west to I-405 south to two lanes throughout. Second, widen the ramp from I-10 east to I-405 north to two lanes throughout and widen the ramp from I-10 east to I-405 south to two lanes. Then, widen the ramp from I-405 north to I-10 east to two lanes and the ramp from I-405 north to I-10 west to two lanes throughout. Finally, widen the ramp from I-405 south to I-10 west to two lanes and widen the ramp from I-405 south to I-10 east to three lanes.

Figure 9: Interchange Design: I-10 and I-405



3. I-5 at I-10

The I-5 at I-10 interchange is located east of downtown Los Angeles in the central part of the region. The interchange is unusually complex and stretches more than a mile from north-south and ½ mile from east-west. The interchange includes two additional expressways: US 101 and SR 60. AADT are 260,000 on I-5 south of the interchange, 233,000 on I-5 north of the interchange, 300,000 on I-10 west of the interchange and 210,000 on I-10 east of the interchange, 190,000 on SR 60 and 200,000 on US 101.

I-5 at I-10 is one of the most complicated expressway interchanges in the country. Fixing this bottleneck requires many steps and some minor expressway widening. First, add one lane to the ramp connecting I-5 north and I-10 west and move the merge to the right side of the expressway. Add one lane on I-5 north from the I-10 west off-ramp to the I-10 east off-ramp. Move the I-10 west merge at I-5 north to the right side of the highway. Add one lane on I-5 south from the I-10 west off-ramp to the I-10 east on-ramp. Widen the ramp from I-5 south to SR 60 east and move the merge to the right side of the highway. Widen the ramp from I-10 west to I-5 north to three lanes and widen the ramp from I-10 east to I-5 south to three lanes and move the merge to the right side of the highway. Widen the ramp from SR 60 west to I-5 north to two lanes. Widen the I-10/US 101 connector from three lanes to four lanes in each direction.

Figure 10: South Interchange Design: I-5 and I-10

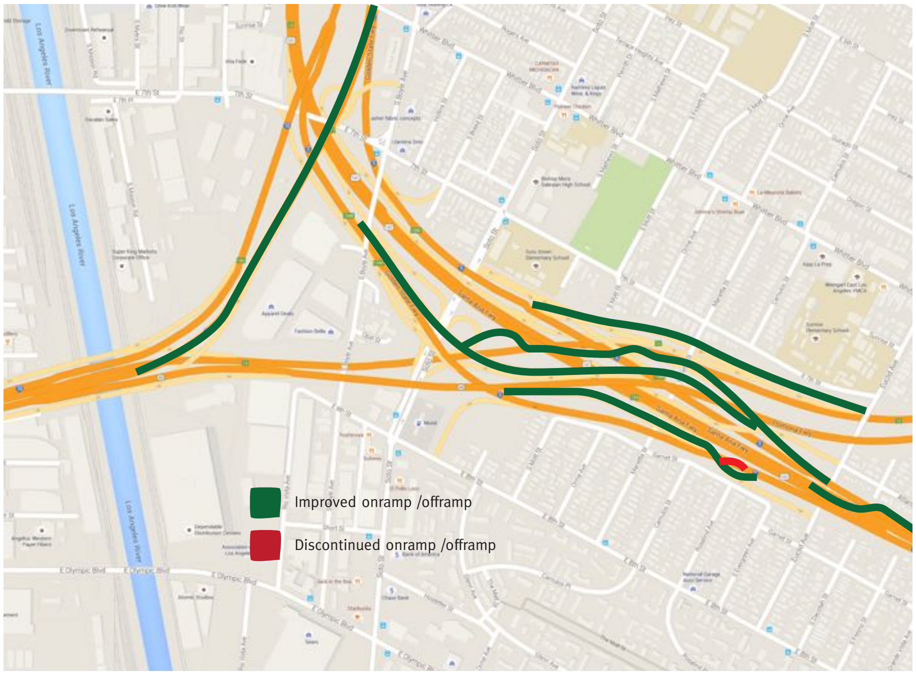


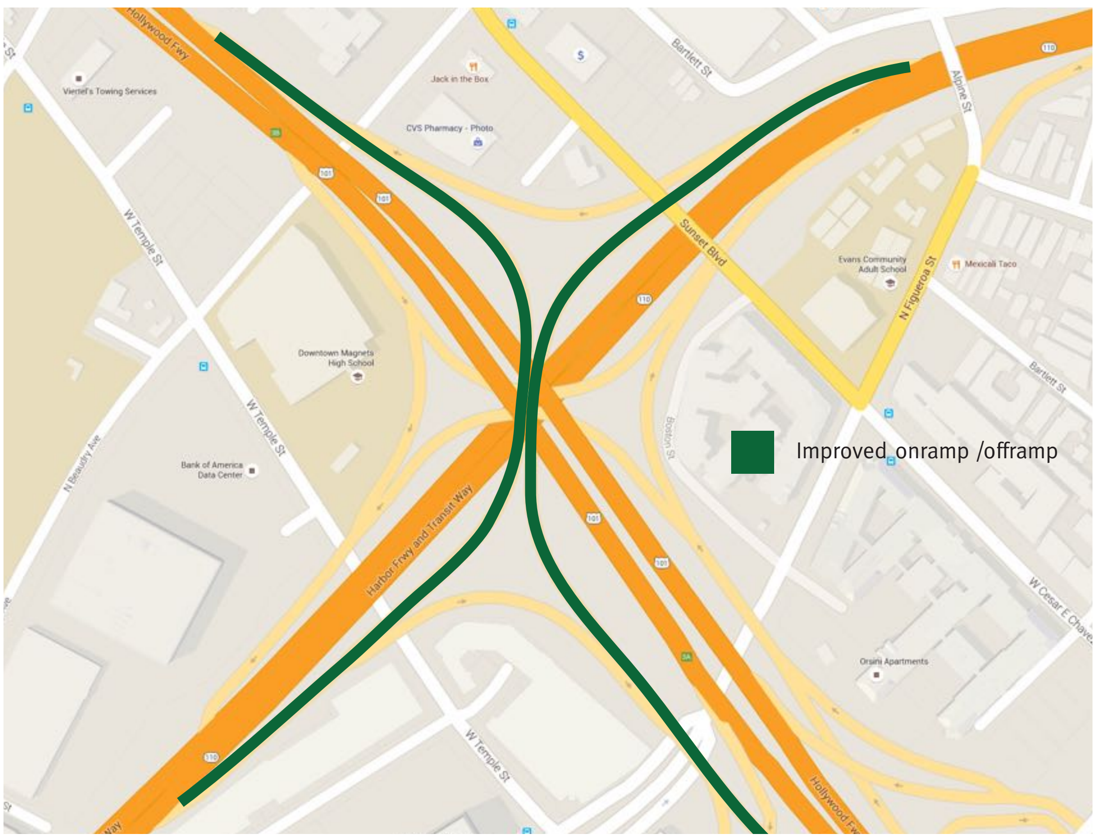
Figure 11: North Interchange Design: I-5 and I-10

4. US 101 at SR 110

The US 101 at SR 110 interchange is located northwest of downtown in the west central part of the region. US 101 has AADT of 180,000, while SR 110 has AADT of 270,000 south of the interchange and 160,000 north of the interchange.

Improving two ramps will cost-effectively improve this interchange. First, widen the ramp from SR 110 north to US 101 north to three lanes. Second, widen the ramp from SR 110 south to US 101 south to three lanes.

Figure 12: Interchange Design: US-101 and SR-110

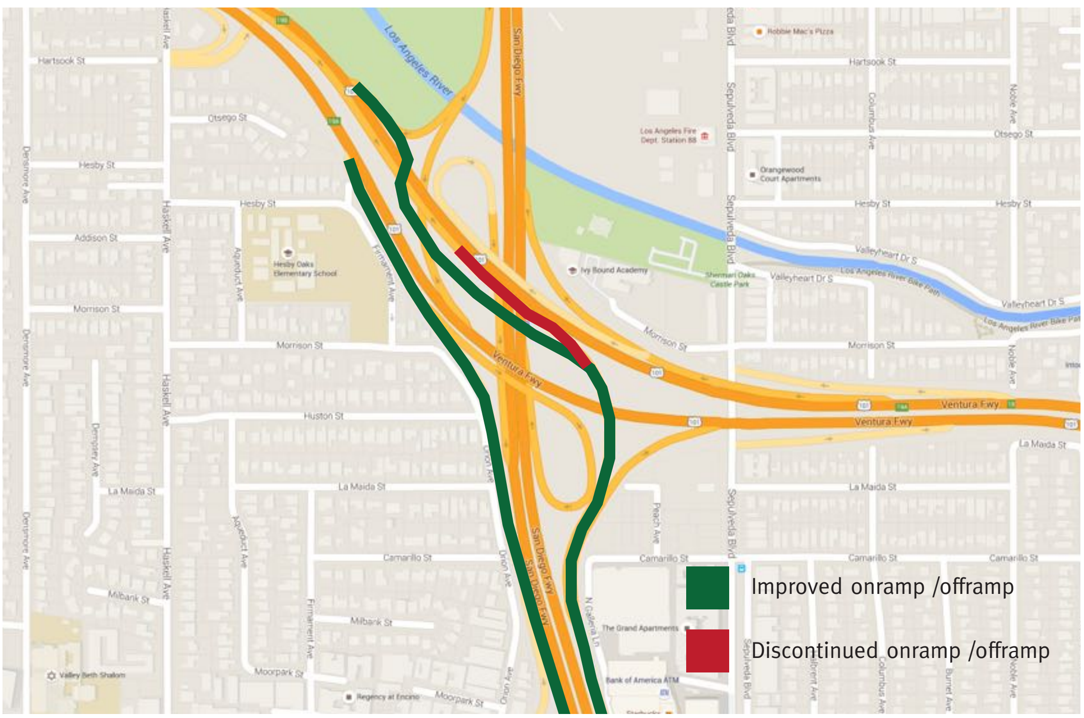


5. I-405 at US 101

The I-405 at US 101 interchange is located in the San Fernando Valley in the northwest part of the region. I-405 has AADT of 280,000 south of the interchange and 210,000 north of the interchange while US 101 has AADT of 300,000.

First widen the ramp from I-405 north to US 101 north to three lanes and move the merge from the left side of the road to the right. Second, widen the ramp from US 101 south to I-405 south to three lanes.

Figure 13: Interchange Design: I-405 and US-101

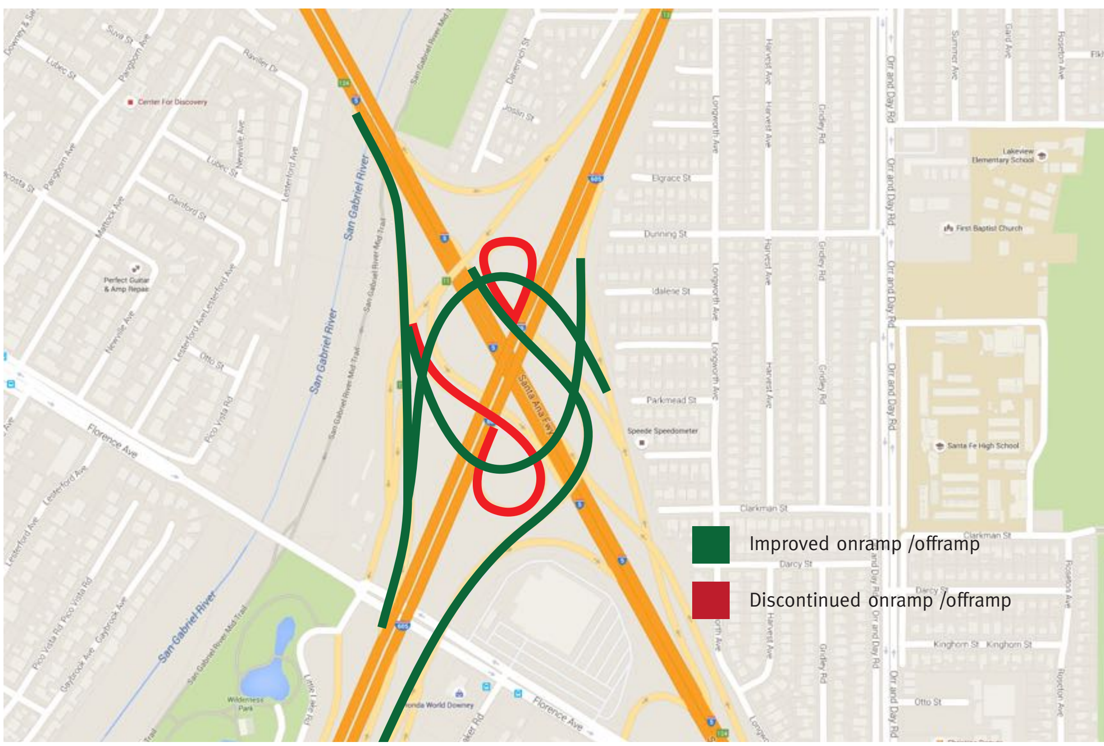


6. I-5 at I-605

The I-5 at I-605 interchange is located near Downey in the central part of the region. I-5 has AADT of 190,000 south of the interchange and 230,000 north of the interchange while I-605 has AADT of 290,000 south of the interchange and 260,000 north.

First, widen the ramp from I-605 north to I-5 north to 3 lanes. Second, widen the ramp from I-5 south to I-605 south to three lanes. Third, replace the loop ramp from I-5 north to I-605 south with a curve ramp and widen it to two lanes. Fourth, replace the loop ramp from I-5 south to I-605 north with a curve ramp and widen it to two lanes.

Figure 14: Interchange Design: I-5 and I-605



7. I-5 at I-710

The I-5 at I-710 interchange is located southeast of downtown in the central part of the region. I-710 is the main expressway connecting the port of Los Angeles to downtown. I-5 has AADT of 250,000 while I-710 has AADT of 200,000.

First, widen the ramp from I-710 north to I-5 north to three lanes and move the merge with I-5 to the right side of the expressway. Second, widen the ramp from I-5 south to I-710 south to three lanes.

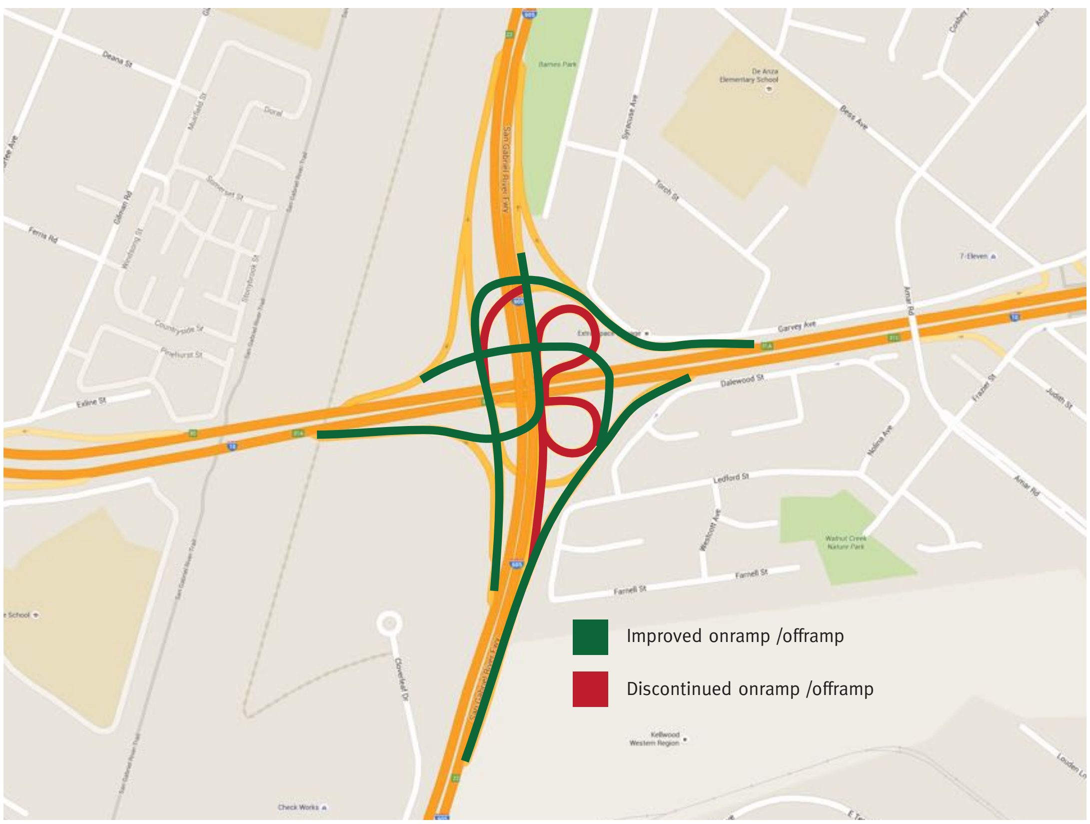
Figure 15: Interchange Design: I-5 and I-710

8. I-10 at I-605

The I-10 at I-605 interchange is located in West Covina in the north central part of the region. I-10 has AADT of 220,000 while I-605 has AADT of 220,000 south of the interchange and 170,000 north of the interchange.

First, widen the ramp from I-10 west to I-605 south to three lanes and move the ramp to the west side of the existing I-605 southbound collector distributor. Then, widen the ramp from I-605 north to I-10 east to three lanes. Replace the loop ramp from I-605 north to I-10 west with a curve ramp and replace the loop ramp from I-10 east to I-605 north with a curve ramp.

Figure 16: Interchange Design: I-10 and I-605

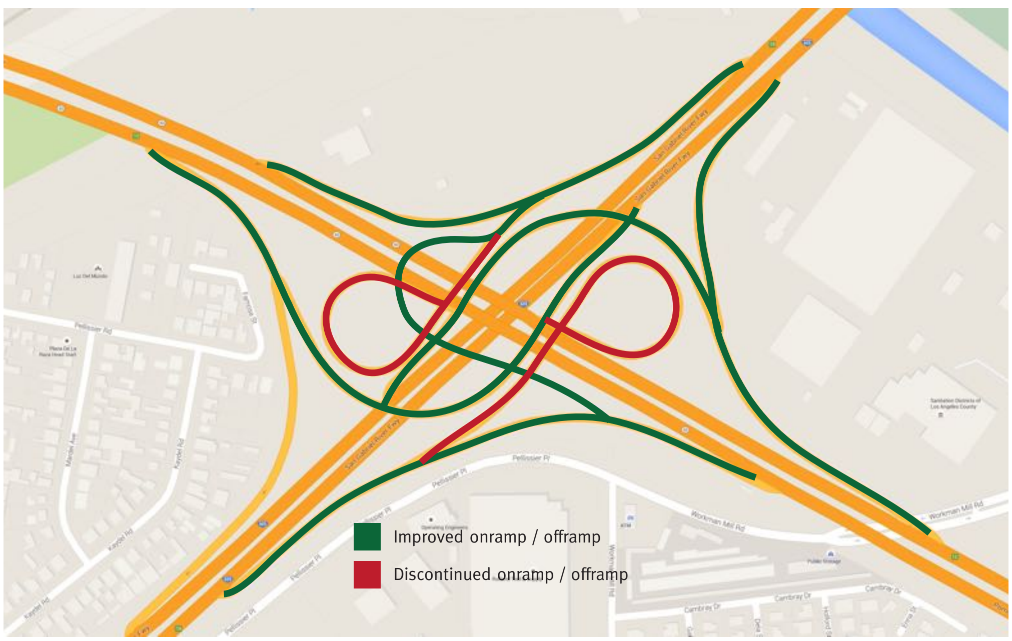


9. I-605 at SR 60

The I-605 at SR 60 interchange is located in the center of the region. I-605 has AADT of 250,000 south of the interchange and 210,000 north. SR 60 has AADT of 250,000.

Widen the ramp from I-605 north to SR 60 east to three lanes. Rebuild the ramp from I-605 north to SR 60 west and eliminate the loop. Widen the ramp from SR 60 west to I-605 north to two lanes. Widen the ramp from SR 60 west to I-605 south to three lanes. Widen the ramp from I-605 south to SR 60 west to three lanes. Widen the ramp from I-605 south to SR 60 east to two lanes and eliminate the loop. Widen the ramp from SR 60 east to I-605 north to three lanes.

Figure 17: Interchange Design: I-605 and SR-60

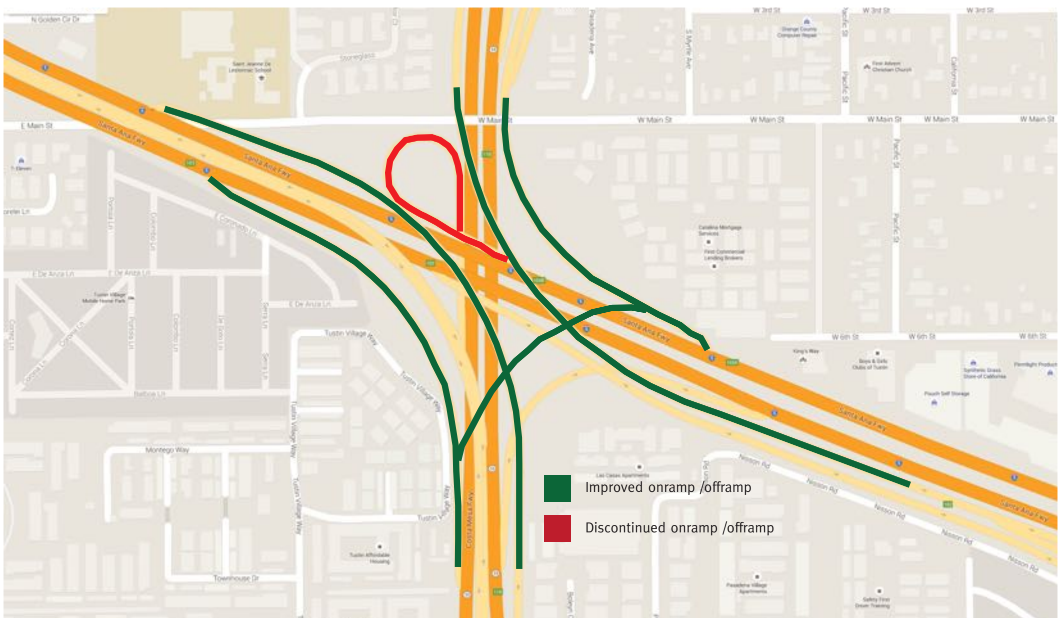


10. I-5 at SR 55

The I-5 at SR 55 interchange is located in Tustin in the southwest portion of the region. I-5 has AADT of 350,000 and SR 55 has AADT of 260,000.

First, widen the ramp from SR 55 north to I-5 north to three lanes. Widen the ramp from I-5 north to SR 55 north to three lanes. Widen the ramp from SR 55 south to I-5 south to three lanes. Widen the ramp from I-5 south to SR 55 south to three lanes. Rebuild the ramp from I-5 north to SR 55 and eliminate the circle curve.

Figure 18: Interchange Design: I-5 and SR-55



B. Expressway-Arterial Bottlenecks

For expressway-arterial bottlenecks, Southern California has a large number of diamond on- and off-ramps not designed for today's traffic. Other ramps feed into local streets before serving the main street, increasing delays and routing through-traffic into neighborhoods. On certain surface streets, ramps are too close together causing unnecessary weaving and congestion.

While there are a number of problematic expressway-arterial bottlenecks, we focused on the interchanges on our proposed managed arterial network, as these are the largest arterials that will have some of the largest traffic increases over the next 25 years.

The full list of interchanges is available in Appendix A, Table A2. All costs were calculated using average cost numbers detailed in Part 3. While fixing bottlenecks at expressway-arterial interchanges will not eliminate congestion around these interchanges, these projects are a cost-effective way to increase mobility.

The goal of these interchange improvements is not to eliminate congestion completely, but to improve badly failing interchanges. These modest improvements will significantly reduce congestion.

Part 5

Making Expressways Reliable: An Express Lanes Network for Southern California

A. Express Lane Overview

A major component of solving Southern California's mobility problem is providing a network of variably priced express lanes on all expressways. Most express lanes are open to light-duty vehicles, including transit buses and vanpools. Express lanes use dynamic pricing to provide a congestion-free travel option.[61] Express lanes are an addition to, not a replacement for, general purpose lanes.

Our report also includes several dynamically priced truck lanes on the busy I-710 and SR 60 corridors that link the Port of Los Angeles and freight distribution centers. These lanes are open to trucks only. While truck congestion can be severe, since most of the worst truck congestion is limited to a few expressways, the truck toll lane network is much more limited in size than the express lane network.

Dynamic pricing varies toll rates in the express lanes based on demand. Most express lane operators use an algorithm that analyzes the congestion level in the general purpose lanes and overall usage of the express lanes.[62] During peak periods, when demand is highest, prices may exceed $1.00 per mile, while during off-peak hours, such as middays and nights, prices may be as low as $0.01 per mile. This variable pricing serves several purposes. First, it guarantees a smooth flow of traffic. This smooth flow of traffic provides reliable travel times 24 hours a day. Second, it reduces induced demand (the tendency for drivers to make extra trips), as pricing provides incentives for motorists to combine trip purposes (known as trip-chaining). Third, it pays for the construction and operation of the express lane network.

Dynamically priced express lanes do not include toll booths. Around the year 2000, the installation of separate drive-thru toll lanes offered customers a way to bypass the tollbooths without having to stop or queue up. This open road tolling (ORT) spread rapidly since it reduced toll plaza congestion and accidents, in addition to reducing toll collection costs. It also eliminated the need for drivers to carry large amounts of cash. Since 2010, toll road operators have been shifting to all-electronic tolling (AET) to dispense with tollbooths and toll collectors entirely. All U.S. express toll lanes have used AET from the outset; none have any kind of toll booths or toll plazas.

How does AET work? Customers are provided a transponder, which is a battery-operated, radio frequency identification (RFID) unit that transmits radio signals.[63] Most transponders are contained within a flexible window sticker. Customers place a sticker in the center of their windshield near the rearview mirror. When the customer passes a toll collection site, an antenna communicates with the transponder and then with a database. The toll is automatically deducted from the customer's prepaid account in the database (or in some cases, the information is used to create a bill).

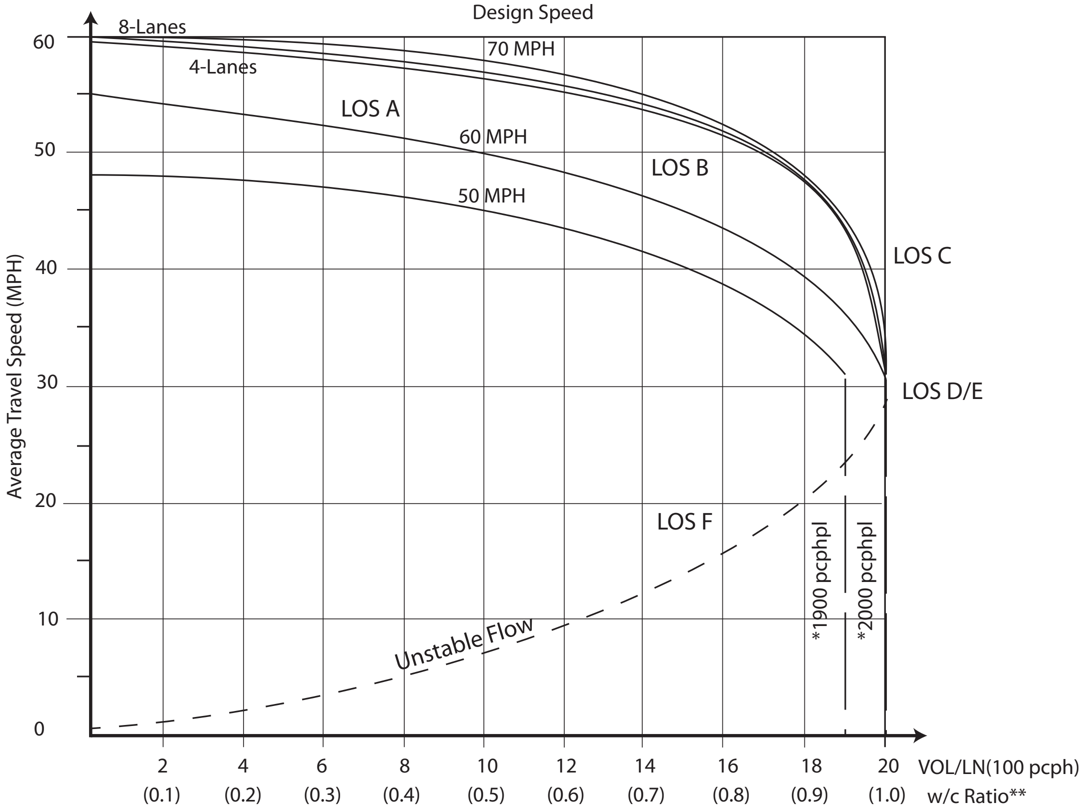
Many express lane operators offer alternatives to AET. Most allow users to pay by license plate. AET collection sites are outfitted with license plate cameras for enforcement purposes. But they also allow the toll agency to bill customers who do not have an AET account by license plate. The toll agency then sends a bill by mail to the customer with a small convenience fee. This fee covers the additional cost of billing and encourages express lane users to get a transponder.

Toll operators are sensitive to the reality that not every customer has or wants to have a credit card.[64] New technology is providing new options for toll payment. Many operators accept personal checks or allow customers to open a cash account or use a debit card. Providing options ensures that all potential customers have at least one easy way to pay for express lane use.

B. Express Toll Lanes Theory

Express lanes use pricing to reduce congestion more effectively than by adding general purpose lanes. Functional capacity can be increased by managing traffic flow in roadway lanes so that these lanes do not get so overloaded into the severely congested state referred to as hyper-congestion.[65] When traffic flow breaks down in that manner, speeds become chaotic and stop-and-go. Under such conditions, the throughput (number of vehicles per lane per hour) of the roadway decreases considerably. Whereas a roadway full of traffic moving steadily at 40 mph may have a throughput of 2,000–2,500 vehicles/lane/hour, if more vehicles try to crowd onto it, the flow rate can degenerate to 1,500, 1,200, or even less as speeds drop into the zero to 20 mph range. These conditions are shown in the traffic engineers' speed/flow curve, in Figure 19. Traffic engineers recognize six levels of service (LOS), ranging from A (uncongested free flow) to F (hyper-congestion). The kind of throughput associated with each is indicated on the figure.

Figure 19: Traffic Engineers' Speed/Flow Curve



*capacity
** v/c ratio based on 2000 pcphpl valid for -60 and 70-MPH design speeds

Source: Federal Highway Administration, Level of Service Guide

Figure 19 shows traffic speed on the vertical axis and traffic volume on the horizontal axis. At the top left, when traffic volume is low, speeds are high and consistent. Engineers refer to this kind of flow as Level of Service (LOS) A. As volume gets higher and cars get somewhat closer together, speeds decline somewhat, and we have traffic at LOS B—still flowing fairly well. Moving to the right, as volume continues to increase, speed declines and we reach the maximum rate of flow that each lane can handle with minimal congestion, designated LOS C. At that point, if more vehicles enter the lane, speed decreases but throughput still increases LOS D. If even more vehicles try to enter, speed declines further, and flow volume is only minimally increased LOS E. Once LOS E is reached, if more vehicles enter, the flow degenerates to stop-and-go traffic. This results in both low speed *and* low volume—called LOS F. Under LOS F conditions, the ability of the roadway to move traffic is hampered at precisely the time it is needed most. Once a roadway gets into severe LOS F, it can sometimes take an hour or more for it to recover.

In a system of dynamic congestion pricing, the price for using express lanes falls if those lanes are clear. But if those lanes start to become congested, the price for using them rises. By deterring drivers who are unwilling to pay the demand-responsive toll, dynamic pricing keeps traffic within the capacity of the tolled roadway, limiting the number of vehicles entering the lane so that traffic always flows at a specified level of service (perhaps C or D during peak periods). Traffic engineers have described this as maintaining traffic at the "sweet spot" represented by the upper right-hand portion of the speed/flow curve.

Express lanes with dynamic pricing are not just a matter of theory. In fact, such pricing was pioneered on the SR 91 Express Lanes in Orange County, in 1995. This proved very successful: during the busiest peak periods Orange County's 91 Express Lanes (a dual-lane facility), the two priced lanes handle 49% of the peak-direction throughput on this six-lane expressway, even though they represent only 33% of the *physical* lane capacity.[66] Thus, priced express lanes operating at LOS C during rush hour have about 50% more *functional* capacity (throughput) than the highly congested (LOS F) general purpose lanes alongside. A single-lane facility of this type can maintain non-congested conditions with about 1,800 vehicles/lane/hour, while a dual-lane facility can handle 2,000 vehicles/lane/hour. The upshot of this is that the SR 91 Express Lanes have remained free-flowing 24 hours a day for the past 20 years, thanks to congestion pricing.

1. Express Lanes Can Incorporate Truck Toll Lanes

Express lanes are not just for cars. Trucks operating on a tight schedule for today's just-in-time warehousing methods can benefit from special truck toll lanes. When trucks need to get somewhere on time, trucks can have the option of using these lanes. But since truck lanes will be slightly wider and built with stronger pavement, trucks may choose to use these lanes even when congestion in the general purpose lanes is minimal, as these lanes will allow truck tires to last longer and provide additional safety to drivers.

The truck lanes will feature the same dynamic pricing as express lanes for cars. Prices will rise and fall based on traffic levels in the general purpose and truck toll lanes to guarantee reliable travel times 24 hours a day, seven days a week.

Since truck lanes are a new concept, and since they will likely only be cost-effective on expressways with the highest traffic volumes, we are recommending building truck lanes on I-710 from the Port of Los Angeles to I-210, on SR 60 from I-710 to I-215, and on I-15 from SR 60 to I-10. These truck lanes are included as part of the express lanes network. Full cost details of the lanes are included in Appendix B.

2. Express Lanes Offer "Congestion Insurance"

Express lanes can continue to offer relief from traffic congestion because as traffic increases over time, future rush-hour prices will be higher than current prices, ensuring the lanes will remain free-flowing over the long-term. This means that motorists can be assured that no matter how bad traffic gets, they will always have a congestion-free option available when they need it.

Some have begun to call this concept "congestion insurance." People purchase insurance to guard against life's other hazards (fire, theft, accidents); similarly, with a network of express lanes, drivers will be able to purchase insurance to guard against being late. The initial cost of this "insurance" is very low: simply the cost of opening an account and installing a transponder on the car's windshield.[67] From that point on, the account-holder has the peace of mind that whenever he/she is running late and really needs to be somewhere on time, he/she has a means of buying that faster trip for a small price.

What kinds of trips might these be?

- Arriving at the day care center on time, before costly per-minute late fees start to mount up;
- Getting to work on time, when the boss has said one more late arrival will be grounds for termination;
- As a tradesperson, accomplishing one more job that day, rather than spending the time waiting in traffic on the roadway; and
- Getting to the airport on time to leave on a business trip or family vacation.

3. Express Lanes Promote Higher Overall Vehicle Occupancy

The goal of higher overall vehicle occupancy (originally intended to be realized via HOV lanes) can be better achieved via an express lanes network for several reasons. First of all, a region-wide set of priced lanes offering major time savings during peak periods gives people an incentive to carpool, so as to split the toll two, three or even four ways.[68] Additionally, the availability of such a network may increase interest in vanpools, since these priced lanes will remain congestion-free indefinitely, unlike HOV lanes which fill up over time and provide little or no time-saving advantages. The long-term sustainability of free-flow conditions makes it worthwhile to invest in vanpooling programs. And lastly, a region-wide, non-congested network makes an ideal guideway for region-wide express bus service. In fact, if a policy decision is made to *reserve* a fraction of the capacity of these lanes for such bus services, and if Metro, OCTA and other area transit agencies plan much of their express bus service around use of this network, then the network would meet the definition of a Virtual Exclusive Busway network providing the virtual equivalent (in terms of bus performance) of a region-wide network of exclusive bus lanes.[69]

4. Express Lanes Are Not Lexus Lanes

Data from express lane projects in California, Florida, Georgia, Texas and Virginia support the premise that most people do not use these lanes twice a day, every day. Rather, most commuters use the lanes in "congestion insurance" mode, once or twice a week. The 91 Express Lanes in Orange County have 176,000 account-holders, but on any given day, only about 33,000 of them use the lanes.[70] And only a small fraction of those 33,000 are everyday commuters; most are those who, on that particular day, had a trip that was worth the toll. The five most common vehicle models in the Georgia Express lanes are the Ford F-150, Toyota Camry, Honda Accord, Toyota Corolla and Nissan Altima.[71] None of these models can be classified as a luxury vehicle.

5. Express Lanes, Not HOV Lanes

Southern California is fortunate to have a network of high occupancy vehicle (HOV) lanes. Los Angeles has one of the most extensive HOV lane networks in the country. Since 1980, Los Angeles County alone has added 438 miles of HOV lanes.[72] There are also extensive HOV facilities in Orange, Riverside, and San Bernardino Counties. The Southern California region as a whole has 813 HOV lane-miles, with a further 84 lane-miles under construction and another 349 lane-miles proposed for the near future. SCAG is also building new express lanes and has plans to transition some HOV lanes to express lanes. Figure 20 shows SCAG's most recent plan for new HOV and HOT lanes in the region. SCAG is updating its express lanes strategy and plans, and is expected to release additional details by 2016.

Figure 20: SCAG Plan Regional Transportation Plan HOV/HOT Network

Source: California Department of Transportation,
http://www.dot.ca.gov/dist07/resources/hov/docs/Interregional%20HOV%20System%20Status.pdf

Originally, controlling vehicle occupancy was the only way to manage lane capacity. And while controlling occupancy can improve mobility at some times of the day, it has a limited effect on the overall network. It is challenging to optimize HOV-network performance. In simple terms, Southern California's HOV lanes suffer from the "Goldilocks" problem. Some HOV lanes are "too hot." During rush hour, HOV lanes on most freeways including I-10, I-110 and I-405 carry far more traffic than originally intended. As a result, cars in the HOV-lane move at approximately the same speed as cars in the general purpose lanes. This situation does not incentivize commuters to carpool or ride the bus. (This excess demand was one reason for transitioning parts of the I-10 and I-110 lanes to HOT lanes.) Most HOV lanes operating outside of peak periods are "too cold." Most HOV lanes between 10 AM and 2 PM, and HOV lanes operating in the reverse peak direction during peak periods carry far fewer cars than their design intended.

The problem with these traditional HOV lanes is that, in order to be efficient, the corridors they serve need to have an exact number of carpoolers. Most corridors may have this traffic volume one to two hours a day but not the rest of the time.

Fortunately, over the last 20 years, technology in the form of variable pricing on express lanes has proven to be a better solution than HOV lanes. During peak-direction rush hours—when demand is highest—express lanes prices are highest. This pricing guarantees a free-flowing trip in the express lanes, and also entices commuters to use the general purpose lanes, a different road, or travel at a different time, if possible. During other times the express lane price is lower, as low at $0.01. This encourages commuters to use the express lanes and shift their travel to the off-peak time where possible.

C. Express Lanes Network

While an individual express lane on one section of expressway can reduce travel times, the most effective express lanes will operate as part of a larger network. The Los Angeles metro area has 30 expressways. Most commuters use at least two of these facilities to commute from their home to work. If only one of the expressways has express lanes, commuters save time for one part of their journey but are stuck in traffic for another part. As a result, the express lane benefits travelers less since it provides travel time savings on only one highway, offering no guarantee of a quicker overall trip.

In addition to the congestion-relieving benefits, a regional express lane network would also generate operating revenue that can be applied to build out the full network within a shorter time frame. Regional express lane networks are being constructed in metropolitan areas throughout the country, including Atlanta, Dallas, Denver, Houston, Miami, Minneapolis, San Diego, San Francisco, Seattle and Washington, D.C.[73] Los Angeles is an excellent candidate for such a network as well, given the large network of existing expressways, the presence of high-occupancy vehicle (HOV) lanes on most of these facilities, and the high levels of traffic congestion.

To maximize the benefits, Southern California needs a complete express lane network on all major expressways to better serve commuters.

1. Which Vehicles Pay to Use Express Lanes?

Two-person carpools (vehicles with two people travel together) are very popular in Southern California. Allowing these vehicles to travel free of charge in the express lanes would lead to congestion undercutting the lanes' value to transit and congestion-reduction benefits for automobiles. Since the number of three-person and four-person carpools drop-off significantly, we recommend offering free passage to vanpools and buses only. Other metro areas including Atlanta and Baltimore have adopted this policy for all newly constructed Express lanes.

As well, most two-person carpools are "fampools," whereby two members from the same family are traveling to the same location.[74] These carpools do not decrease congestion because these commuters would travel together without an incentive. In some cases a two+ person carpool lane actually induces congestion by encouraging parents to drive their kids to school instead of sending them on the school bus. Clearly this is not the intended goal of HOV lanes.

In order for such express lane policies to be enacted, it is important for planning agencies in Southern California to work closely with the public to explain the magnitude of the congestion problem, the true cost of congestion to the economy and quality of life, and the merits of congestion pricing.

2. Express Lane Conversions

Since express lanes are more effective than HOV lanes, we recommend converting all HOV lanes to express lanes. With approximately 900 miles of HOV lanes in operation or under construction, converting all lanes to express toll lanes would provide a major benefit.

New Capacity

To create a complete express lane network, Southern California needs to add tolled physical capacity to expressway corridors that do not have existing HOV lanes to convert. Other corridors have only one HOV lane in each direction but need two express lanes per direction to enhance mobility. Table B1, located in Appendix B, details where to add lanes and how many lanes to add. The table also delineates the total number of express lanes recommended for each freeway corridor.

Given the extreme levels of congestion on most of the region's expressways, we recommend a network with two express lanes in each direction. However, certain corridors justify more or fewer express lanes. Generally, we recommend one express lane per direction on expressways with current level of service "C" during peak hours with between 80,000 and 150,000 average annual daily traffic (AADT), and fewer than 20,000 AADT per lane. We recommend two express lanes per direction on expressways with current level of service "D" and "E" during peak hours, with between 150,000 and 300,000 AADT and between 20,000 and 28,000 AADT per lane. We recommend three express lanes per direction on expressways with current level of service "F" during peak hours and more than 300,000 AADT and more than 28,000 AADT per lane. The exact number of proposed lanes also varies based on other factors, such as construction costs, roadway geometry, seasonal variation, percent of truck traffic and expected growth rate over 35 years.

Building express lanes by themselves is not sufficient. As discussed above, most of the region's commuters use multiple expressways to commute from point A to point B. If commuters need to transition from the express lanes to the general purpose lanes to exit expressway A and then move from the general purpose lanes to the express lanes on expressway B, they will be subject to significant congestion at many interchanges. Such congestion will decrease the value of the express lanes. As a result, we also need to build flyover connectors between express lanes on different expressways to provide uncongested trips. Some such connectors already exist in Orange County, but they are less common elsewhere in the region. Table B2, located in Appendix B, details the express-lane-to-express-lane connectors needed for the network to operate optimally. The following figures, 21 and 22 illustrate the Southern California Express Lanes Network.

Figure 21: Southern California Express Lanes Network (South)

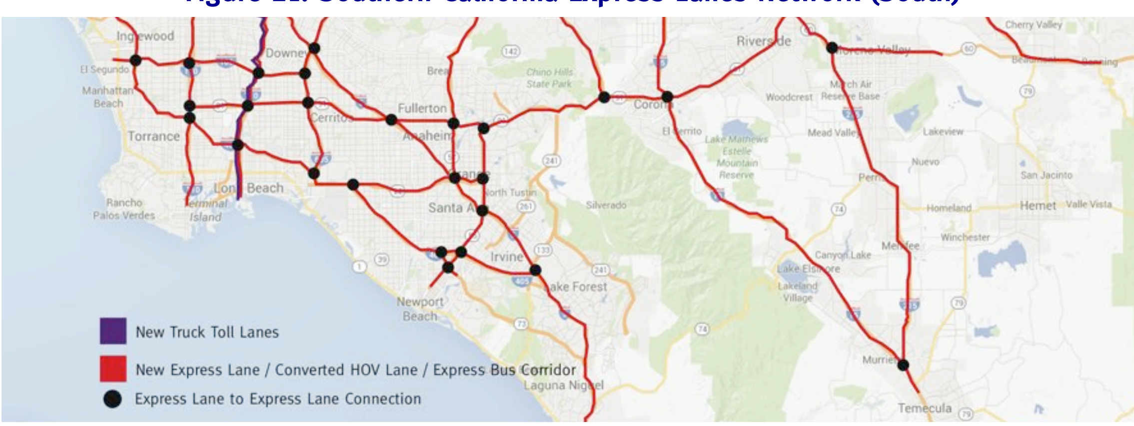
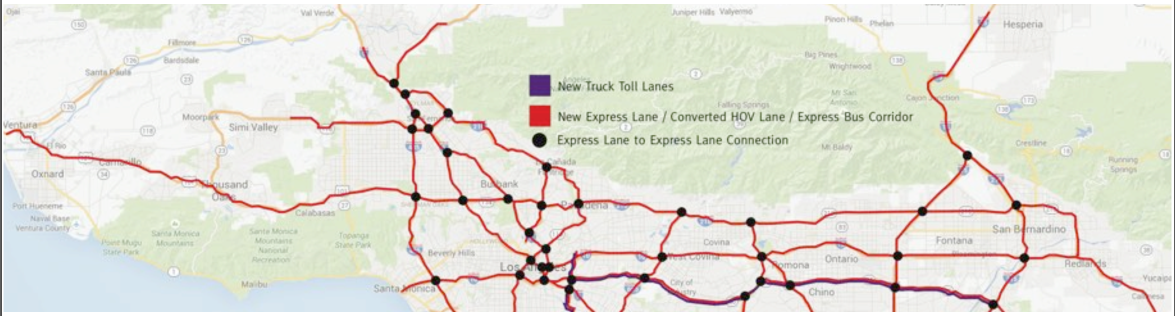


Figure 22: Southern California Express Lanes Network (North)



D. Financial Feasibility

While express lanes are growing in popularity throughout the country, many regions need to supplement toll revenue with gas tax revenue in order to have the resources to build and operate an express lane network. However, due to the Southern California's extreme congestion, high express lane usage and relatively high express lane tolls, tolls are projected to be large enough to comfortably pay for the construction, operation and maintenance of the entire network.

We model the express lanes as being constructed over 25 years. We propose that 20% of the network is built during each five-year window. We calculate toll revenue as growing at the rate of inflation (2.9%) and start tolling when the project opens to the public. We work from a toll revenue base of 40 years, as that time period is the expected life of the infrastructure. We recommend that the express lanes facility be constructed as a public private partnership due to the cost-savings over the life of the facility.

The following table provides an overview of the Express Lane network funding and financing. More details including Net Present Value calculations are displayed in Appendix D.

Table 15: Express Lane Network Costs at a Glance

Region	Gross Revenue	Net Revenue	Construction Cost	Transfer to Expressways/Tunnels	Contingency	Debt Service
Los Angeles	$204.9B	$174.2B	$129.0B	$7.2B	$11.8B	$26.2B

Table 15 shows several important express lane numbers. The total gross revenue collected over the lifetime of the project is $204.9 billion. We deduct 15% of the gross revenue to use for roadway operations and maintenance. The remaining 85%, $174.2 billion, is the net revenue.

The construction cost totals $129.0 billion. We use $7.2 billion of the total to fill in the gap in the new tolled expressways/tunnels described later in this paper. We devote the remaining resources to a combination of contingency costs and debt service.

Since express lane usage depends upon one's willingness to pay, which can vary based on economic circumstances, we have included $11.8 billion in contingency costs in case construction costs are higher than forecast and/or usage is lower than forecast. Even with the contingency, the tolling revenue still covers 100% of the construction, operations and maintenance of the network.

We do expect some express lane segments to recover close to 150% of their costs, while others may recover only 50%. However, the express lanes will only work if the lanes function as a true network, whereby all residents can have a congestion-free, predictable travel time from point A to point B on multiple expressways. More financial details are available in Appendix B.

Part 6

Taming Surface Road Congestion: Managed Arterials

The fourth part of solving Southern California's mobility problems is developing a comprehensive surface street network to serve as an alternative and complement to the extensive expressway network. Our proposed managed arterial concept offers a congestion-free trip on even the busiest arterials, providing additional options for buses and motorists throughout the region.

A. How Managed Arterials Work

Express lanes have helped revolutionize expressway travel by providing a quick, reliable trip for buses, vanpools and drivers willing to pay a toll to bypass congestion. Express lanes work because they are on limited access expressways that can easily be tolled. But most of the road mileage in major metro areas is on arterials, which function very differently. Arterials are high-capacity roads that primarily connect expressways and collector roads at the highest level of service.[75] They feature multiple intersections with side roads, shopping centers and businesses. Because of this, managing arterial lane capacity and traffic flow via tolling is much more challenging.

A "managed arterial" is an arterial that has been upgraded with a series of grade separations at major intersections. The managed arterial offers drivers the choice of using an underpass (or in selected cases, an overpass) to bypass the intersection and traffic light.[76] These underpasses allow an arterial to provide the same type of dependable travel time as an express lane. Since the largest chokepoints on arterials are traffic signals at major cross streets, creating grade separations at these intersections is the optimal way to relieve back-ups and congestion. Managed arterials relieve traffic congestion and offer quality transit service on busy arterials.

Limited resources make funding underpasses very challenging, but managed arterials can be financed similarly to express lanes. Managed arterials operate on the same general concept as express lanes as they offer drivers a choice of paying a small fee to use optional lanes to bypass traffic. These underpasses can be partially paid for by charging a small toll, generally $0.25 to $0.50 per crossing, depending on the size of the intersection and the congestion.[77] To keep the cost and complexity low, all electronic tolling (AET) is used. AET uses transponders or sensors to determine the number of axles per vehicle and the corresponding toll rate. Then toll readers automatically deduct the correct toll amount from the customer's account. Drivers can also choose to continue on the main road and proceed through the signalized intersection for free.

Through using underpasses, managed arterials provide uninterrupted traffic flow across the intersection. Managed arterials also will lead to reduced congestion in the non-tolled lanes since many previous lane occupants will choose to use the underpasses. In this way the managed arterial provides not only more capacity but a different option, which does not further constrain the intersection, as the mere adding of lanes would do.

Figure 23 is an example of a managed arterial underpass. Figure 24 is an example of a managed arterial overpass.

Figure 23: Managed Arterial Underpass

Figure 24: Managed Arterial Overpass

To compute the throughput capacity of a managed arterial, we use a six-lane arterial, with two grade-separated lanes in each direction at major intersections and one at-grade through-lane in each direction (plus turn lanes) at major intersections. The hourly (peak-hour/peak-direction) capacity is calculated using standard DOT figures based on a four-lane, divided, uninterrupted flow facility plus one-half of the capacity of a four-lane, divided, minor arterial. In order to provide higher quality service for drivers using the tolled grade separations and to offer high-quality bus service, the roadway must operate at LOS C or better.

Many metro areas are converting or building bus-only lanes on arterials. While increasing the quality of bus transit may be an important goal, dedicating a full lane to bus travel may not be the most efficient approach. Table 16 displays the throughput capacity of a managed arterial. Table 17 compares a managed arterial to a six-lane arterial with two bus-only lanes.

Table 16: Hourly Directional Throughput Capacity of a Six-Lane Managed Arterial

Transit Percentage (person trips)	Vehicle Capacity (vph)	Cars per Hour	Auto Throughput (persons per hour @ 1.15 persons per vehicle)	Transit Through- put (persons per hour)	Required Buses per Hour (40 person capacity)	Total Vehicles per Hour	Total Throughput (persons per hour)
0%	3,225	3,225	3,709	0	0	3,225	3,709
2%	3,225	3,223	3,706	75	2	3,225	3,781
4%	3,225	3,221	3,704	153	4	3,225	3,857
5%	3,225	3,220	3,704	195	5	3,225	3,899
10%	3,225	3,214	3,696	409	11	3,225	4,105
15%	3,225	3,208	3,689	649	17	3,225	4,338
20%	3,225	3,202	3,682	920	23	3,225	4,602
25%	3,225	3,194	3,673	1,224	31	3,225	4,897
30%	3,225	3,185	3,663	1,567	40	3,225	5,230
32%	3,225	3,181	3,659	1,721	44	3,225	5,380
33%	3,225	3,180	3,657	1,797	45	3,225	5,454
34%	3,225	3,177	3,654	1,882	48	3,225	5,536

Table 17: Hourly Directional Throughput Comparison: 3 GP Lanes vs. 2 GP Lanes + 1 Bus-only Lane

Lanes	Demand (persons per hour)	Percent Transit	Vehicle Capacity of GP Lanes	Required Cars to Meet Demand in GP Lanes	LOS - GP Lanes	Transit Through- put (persons per hour)	Required Buses per Hour (40 person capacity)	Demand Beyond Capacity (vehicles per hour)	Demand Beyond Capacity (persons per hour)
3GP	3,250	0%	2,830	2,826	E	0	0	0	0
2GP+1Bus	3,250	0%	1,870	2,826	F	0	0	956	1,100
2GP+1Bus	3,250	2%	1,870	2,770	F	65	2	901	1,036
2GP+1Bus	3,250	4%	1,870	2,713	F	130	3	846	973
2GP+1Bus	3,250	5%	1,870	2,685	F	163	4	819	942
2GP+1Bus	3,250	10%	1,870	2,543	F	325	8	682	784
2GP+1Bus	3,250	15%	1,870	2,402	F	488	12	544	626
2GP+1Bus	3,250	20%	1,870	2,261	F	650	16	407	468
2GP+1Bus	3,250	25%	1,870	2,120	F	813	20	270	310
2GP+1Bus	3,250	30%	1,870	1,978	F	975	24	133	153
2GP+1Bus	3,250	32%	1,870	1,922	F	1,040	26	78	89
2GP+1Bus	3,250	33%	1,870	1,893	F	1,073	27	50	58
2GP+1Bus	3,250	34%	1,870	1,865	E	1,105	28	0	0

Note that for all percentages of transit use, the managed arterial has a significantly higher person throughput than a six-lane arterial configured for four general purpose lanes and two bus-only lanes. At 4% transit use, the six-lane managed arterial is able to move 3,857 persons per hour compared to 2,240 persons on the 4 GP/2 bus-only arterial. In this case the managed arterial has a person capacity 72% greater than the 4 GP/2 bus-only arterial, while maintaining a significantly higher LOS. At a transit usage of 34%, if that could actually be attained, the managed arterial would still provide almost 70% greater person throughput, again at a higher level of service.

An option to a six-lane managed arterial is an eight-lane arterial (six GP plus two bus-only lanes). A six-lane managed arterial does not require any more extra right of way than an eight-lane arterial. In fact, given that the seventh and eighth lanes would have to be maintained through the entire length of the facility, not just at the intersections, a six-lane managed arterial will require less right-of-way overall than an eight-lane arterial. The throughput capacity of an eight-lane arterial that includes two bus-only lanes is shown in Table 18.

Table 18: Hourly Directional Throughput Capacity of 8-Lane Arterial with 6 GP + 2 Bus-Only Lanes

Transit Percentage (person trips)	GP Lanes Vehicle Capacity (vph)	Cars per Hour	Auto Throughput (persons per hour @ 1.15 persons per vehicle)	Transit Throughput (persons per hour)	Required Buses per Hour (40 person capacity)	Total Vehicles per Hour	Total Throughput (persons per hour)
0%	2,830	2,830	3,255	0	0	2,830	3,255
2%	2,830	2,830	3,255	66	2	2,832	3,321
4%	2,830	2,830	3,255	134	4	2,834	3,389
5%	2,830	2,830	3,255	171	5	2,835	3,426
10%	2,830	2,830	3,255	363	10	2,840	3,618
15%	2,830	2,830	3,255	572	15	2,845	3,827
20%	2,830	2,830	3,255	819	21	2,851	4,074
25%	2,830	2,830	3,255	1,079	27	2,857	4,334
30%	2,830	2,830	3,255	1,378	35	2,865	4,633
32%	2,830	2,830	3,255	1,533	39	2,869	4,788
33%	2,830	2,830	3,255	1,604	41	2,871	4,859
34%	2,830	2,830	3,255	1,676	42	2,872	4,931

Managed arterials have several advantages over bus-only lanes. However, Southern California also must work to improve its bus service. Part 10 provides details on how to improve the region's transit network.

While converting a six-lane arterial into a managed arterial is slightly more expensive than widening the six-lane arterial to an eight-lane arterial, managed arterials can be paid for through tolls. In Southern California, tolls will support 100% of the project's construction, operating and maintenance costs. Traditional arterial widenings, which cost $10–$20 million a mile and sometimes more, are paid for by all motorists or all taxpayers regardless of whether they use the road or not.[78]

All of these factors make managed arterials an attractive option for policymakers trying to improve transit and reduce traffic congestion. However, the managed arterial concept is still evolving. Managed arterials were first studied in Lee County, FL (Fort Myers) under the Federal Highway Administration's Value Pricing Pilot Program, in 2002. The study examined the possibility of using grade-separated overpasses at congested intersections to allow drivers who were willing to pay a toll to bypass the traffic signal and its queue.[79] It also examined operational issues, public acceptance and cost feasibility, finding that from an operations standpoint such grade separations are feasible. There are no technical or operational issues that would prohibit their use. With some (non-tolled) grade-separated intersections already in existence in Lee County, this was not a surprising finding.

Reason Foundation helped develop the concept of a managed arterial that was presented in 2012 at the National Academy of Sciences Transportation Research Board (TRB) Annual Meeting. A paper on the subject has been published in TRB's journal, *Transportation Research Record* No. 2297.[80]

B. Managed Arterials Revenue Estimation

The managed arterials pricing model is to charge a flat rate toll, adjusted annually for inflation and traffic growth, for each grade separation (underpass or overpass). The 18 managed arterials described previously and detailed in Appendix C proposes 559 newly constructed grade separations—underpasses or overpasses. Both the toll rates and the usage rates are based on previous studies that were undertaken for tolled, grade-separated interchanges in Lee County, Florida and adjusted for Southern California's unique congestion challenges.

The throughput of a six-lane arterial reconfigured as a managed arterial is up to 87,600 average annual daily traffic (AADT). Since SCAG projects that most of these corridors will operate at LOS F in 2035, we assume that during peak and shoulder periods on weekdays, the arterials will operate at capacity, with the managed arterial grade separations operating at LOS C. We also make the following assumptions:

- Of the total AADT, traffic equal to half that amount (43,800) occurs during eight peak hours, and another quarter (21,900) during four shoulder hours, with the balance during the remaining 12 hours.
- 2015 toll rates per tolling point (each grade separation used) are assumed to be $0.35 peak, $0.25 shoulder, $0.15 during off-peak hours and $.20 during the weekends.
- Based on the speed advantage of avoiding signaled interchanges, we assume that 50% of total arterial traffic opts to use the underpasses/overpasses rather than the signalized intersections lanes during peaks, 35% during shoulders, and 20% during off-peak hours and on weekends.

The assumption that 50% of total traffic approaching the intersection will use the grade separation during weekday peak periods may seem high, but there are good reasons for making this assumption. First, the underpass or overpass will provide a large amount of capacity, four lanes (two in each direction). Second, while the toll rate is easily adjusted, the congestion at the intersection is affected by the signal timing. Besides through-traffic, the signalized intersection must also serve left, right and U-turns as well as cross-street through-movements and turns. The best policy that minimizes total overall delay at the intersection is to maximize use of the grade separations. The best way to maximize use of the grade separations is to shift "green time" (green time is the time allotted to movements through the intersection and is usually expressed as a percentage) no longer needed by the through-movements to the other movements, thereby reducing overall delay.

Table 19 summarizes the calculation, based on the above assumptions.

Table 19: Managed Arterial Network Revenue Estimation

Time of Day	Traffic	Percent Traffic Using	Rate per Grade Separation	Number Used	Daily Revenue
Peak	43,800	50%	$.35	559	$4,284,735
Shoulder	21,500	35%	$.25	559	$1,051,619
Off-peak	21,500	20%	$.15	559	$360,555
Total Weekday					$5,696,909
Weekend & Holiday	52,560	20%	$.20	559	$1,176,136

With 250 weekdays per year, the annual revenue from weekday use is $1,424,227,188. The 115 weekend and holiday days yield an additional $135,255,640. After accounting for rounding, the annual total for all the managed arterial grade separations is $1,559,379,972.

We calculated that the managed arterial network will cost $53.1 billion over 25 years in inflation-adjusted dollars to construct. This includes the overpasses/underpasses and some minor road improvements. Similar to the express lanes, we recommend building 20% of the network over each five-year period until the entire network is constructed. Also similar to the express lane network, we recommend using P3s to stretch public resources further. The following chart compares the cost to build the system with the toll revenue.

Table 20: Managed Arterials Costs versus Revenue

Region	Gross Revenue	Net Revenue	Construction Cost	Contingency	Debt Service
Southern California	$114.9B	$97.7B	$53.1B	$20.7B	$23.9B

Table 20 includes several key numbers. The gross revenue is the total amount of toll revenue collected over 40 years. Revenue from the optional tolled grade separations on the managed arterial provides $114.9 billion in gross revenue. We deduct 15% of the gross revenue to use for roadway operations and maintenance. The remaining 85%, or $97.7 billion, is the net revenue. The construction costs are estimated at $53.1 billion.

Since no managed arterial network has been built in the U.S., we think it is crucial to include a large contingency in case construction costs are higher than forecast and/or usage is lower than forecast. We understand that a $20.0 billion contingency (18%) of total costs is high. However, we think the managed arterials are so crucial to Southern California reducing both its arterial congestion and improving its BRT service that these lanes need to be constructed. As a result we want to ensure a sufficient contingency for any surprises that may arise.

As Table 20 shows, the Southern California region's managed arterial network tolls easily cover construction, operating and maintenance costs, even with a 20% contingency. The positive modeling results indicate that Southern California is a great candidate for managed arterials.

C. Creating a Managed Arterial Network

Clearly, not every arterial in Southern California is appropriate as a managed arterial. Our plan proposes a managed arterial network—similar in structure to, but smaller in size than, the existing expressway network—that 1) develops a complementary system to ease expressway congestion and 2) fills in gaps in the expressway network. Expressways and arterials work in tandem to provide travel guideways for motorists and transit buses. Analysis suggests that managed arterials are most effective with six travel lanes in each direction. As a result, some sections of these proposed managed arterials are shown as being widened. The number of widened sections is extremely limited and conversions of parking lanes or auxiliary lanes were suggested where feasible.

We estimate that tolls would cover approximately half of the managed arterial costs. The rest of the costs will come from gas taxes, mileage-based user fees, or other road charges.

Our plan includes 18 managed arterials. Eleven run north-south while seven run east-west. All routings are approximate. Figures 25 and 26 illustrate our managed arterials network. The exact routings and details on the various managed arterials components are delineated in Appendix C.

Southern California policymakers will also need to devote some resources to improving minor arterials and local streets. These parts of the roadway network are beyond the scope of this study. Where possible, Southern California should fill in the existing road network and develop feeder streets to primary arterials and expressways.

Figure 25: Managed Arterial Networks

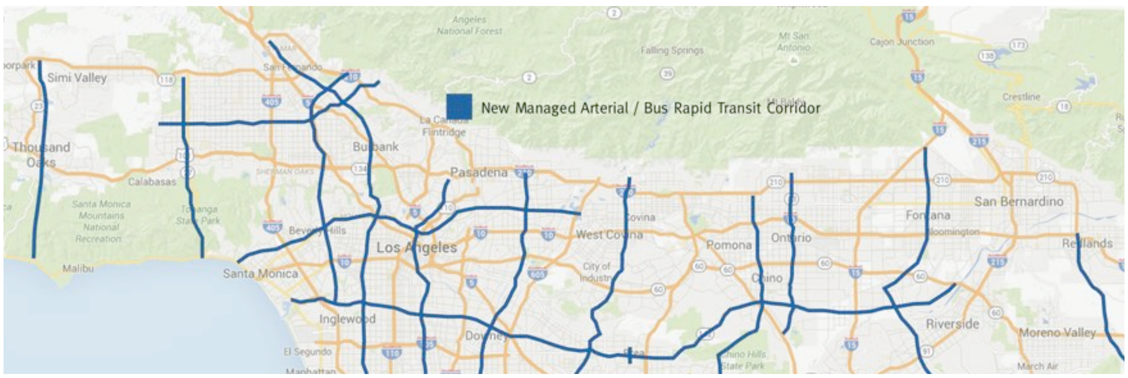
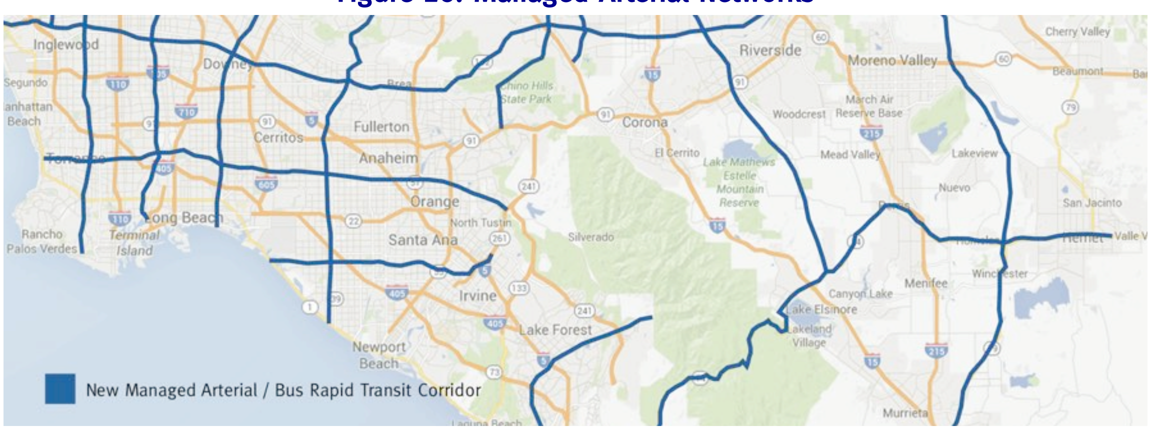


Figure 26: Managed Arterial Networks



Part 7

Filling in Missing Links in the Expressway Network via New Tolled Capacity

A. Identifying the Gaps

The third part of solving Southern California's mobility problem involves providing long-needed missing links in the expressway system to reflect the actual land uses and travel patterns of the Los Angeles metropolitan region. Given the shortage of conventional transportation funding, these new projects would have all lanes electronically tolled, and would use toll revenue to finance major portions of the costs.

To help more effectively manage congestion, we recommend building the following six expressway projects:

- Project 1: I-710 Extension (I-710T): A tunnel that extends I-710 north from Los Angeles to connect with I-210 in Pasadena.
- Project 2: High Desert Corridor (HDC): A new expressway between SR 14 in Palmdale and I-15 in Victorville.
- Project 3: Glendale-Palmdale Tunnel (GPT): A tunnel extending north from SR 2 in the Glendale area and connecting with SR 14 just south of Palmdale.
- Project 4: Irvine-Corona Freeway (ICE): A new combination expressway corridor/tunnel between Riverside and Orange Counties.
- Project 5: Cross Mountain Tunnel (XMT): A new combination expressway/tunnel connection between US 101 in the San Fernando Valley and I-10 in West Los Angeles.
- Project 6: Downtown Bypass Tunnel (DBT): A tunnel extension of SR 2 south through central Los Angeles to I-110.

Among these six projects, Project 1 (the I-710 Gap Closure Tunnel) and a portion of Project 2 (the High Desert Corridor) are included in the SCAG Financially Constrained 2012 RTP. We propose both projects as value-priced tolled facilities to maximize vehicle throughput and congestion relief, to provide an uncongested option, and to generate most of the revenue needed to build and maintain the facility beyond what is already in the SCAG Plan.

The other four projects represent an expansion or modification of the projects contained in the SCAG RTP. The projects have not been modeled for air quality compliance, though our overall modeling work showed that the proposed set of projects would slightly reduce overall vehicle-miles traveled (as more vehicles shift from arterials to more-direct freeway and toll-lane routes).

Implementing these projects would represent a huge, one-time catch-up in network capacity to better match the system's capacity to the growth in population and travel over the past 20–30 years during which expressway capacity additions were limited.

The remainder of this chapter details each of the major projects. For each project, an overview of the project, project rationale, project status and location map are provided. Toll rates and traffic volumes are detailed for each project. After all the projects have been introduced, we examine combinations of projects to analyze how the new facilities will work together. Finally, we estimate the total cost for each project. We examine the ratio of project costs to user benefits and the advantages of building tunnels compared to surface roads.

A summary of benefits for each of the six projects is provided next. Results are based on the Southern California Association of Governments (SCAG) regional travel demand model, including the year 2035 traffic model, the year 2035 road network, and year 2035 origin-destination matrices for six vehicle classes.

A more complete description of project benefits, including the analysis methodology and findings, are provided as Appendix D to this report.

B. Project Details

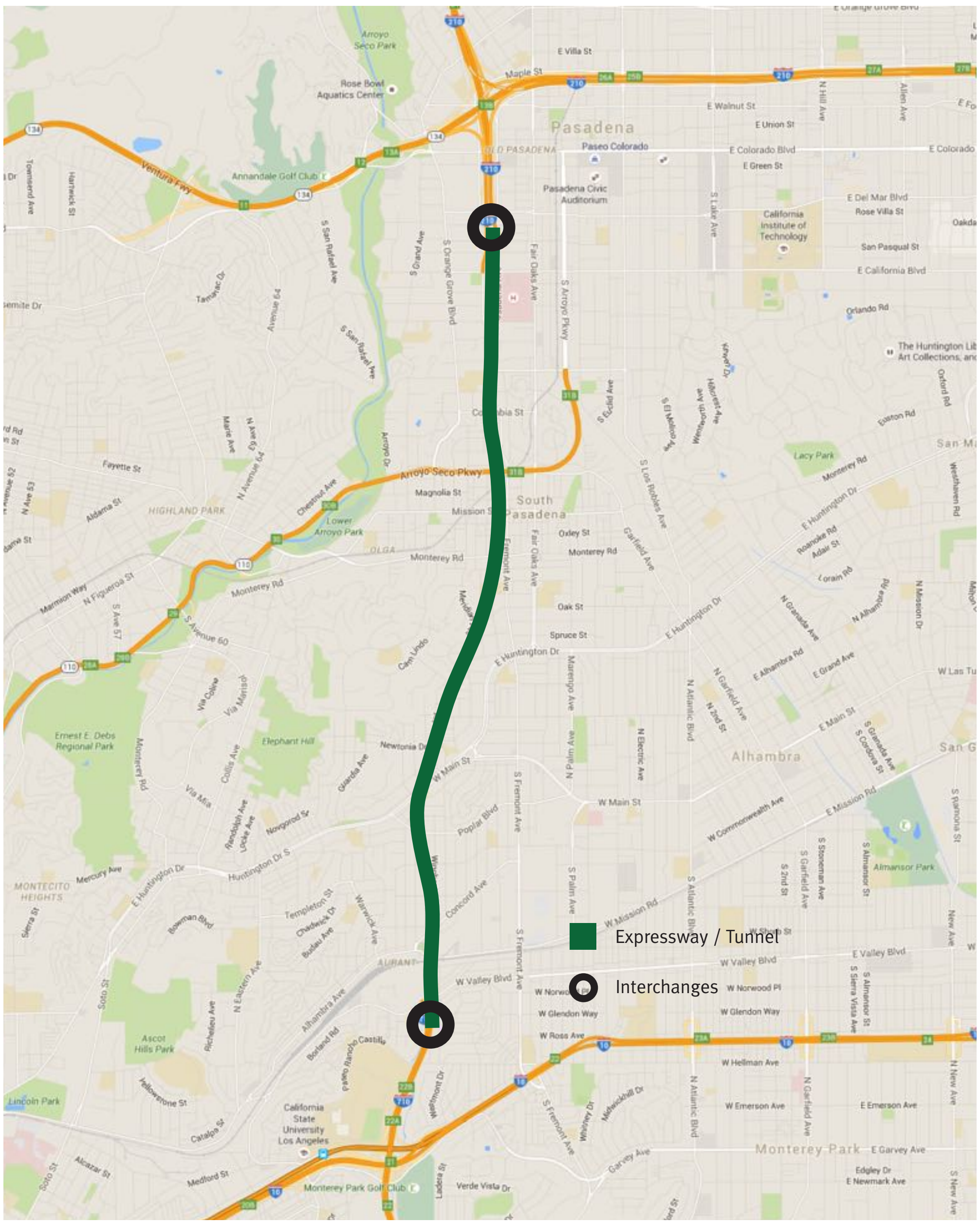
Project 1: I-710 Extension

The I-710 expressway is an extensively traveled facility but has a 4.5-mile gap between Valley Boulevard, just north of the I-10 San Bernardino Expressway in the City of Los Angeles and Del Mar Boulevard in the City of Pasadena. The expressway continues from Del Mar Boulevard to the junction of the I-210 Foothill Expressway. Closing the gap relieves regional and local traffic congestion, particularly on I-5 and I-10, and enhances air quality. Surface expressway alternatives to close the gap have not advanced due to community and environmental concerns.

A 4.5-mile tunnel option with an additional 1.2 miles of surface construction, extending I-710 north to connect with I-210, completes this important link in the network and is viable from an engineering and a financial standpoint. Filling in this missing link significantly reduces congestion on the expressways in that part of the metro area as well as on the surface streets of Alhambra, South Pasadena, Pasadena, and nearby cities. Perhaps more importantly, this missing link would provide travelers with another expressway option between North Los Angeles County and the South Bay to complement the highly congested I-5, US 101 and I-405 expressways.

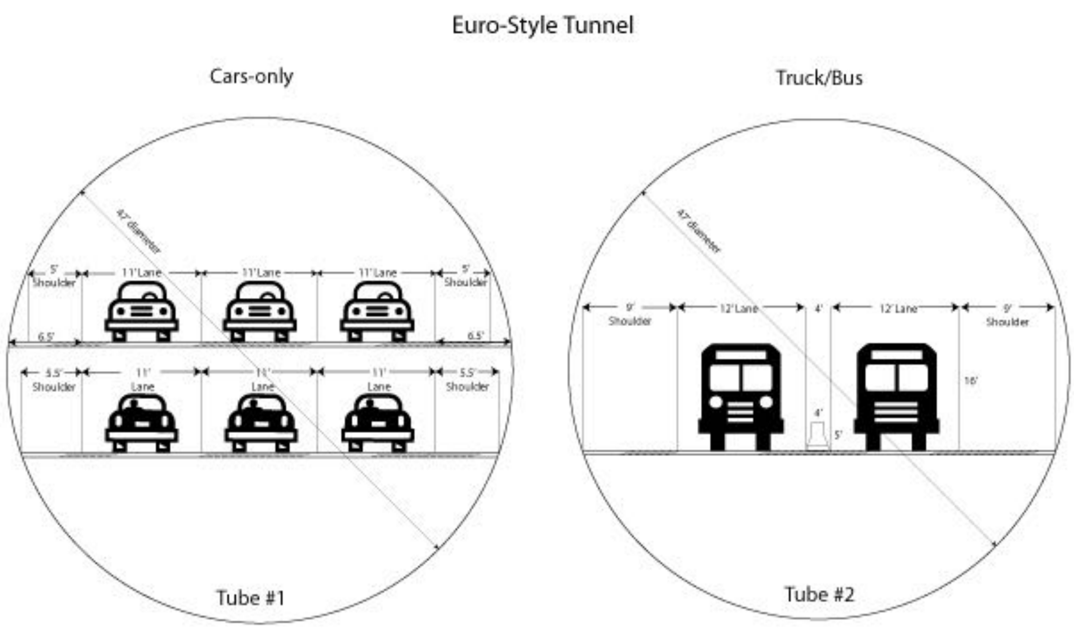
This tunnel is included in the SCAG Financially Constrained RTP, and does not split South Pasadena or create the environmental impacts of a surface project.[81] Figure 27 shows the I-710 Extension project study area.

Figure 27: I-710 Extension Study Area



For this project, two 46-foot inner diameter (50-foot outer) tunnels are to be constructed using two tunnel-boring machines (TBMs). Construction is forecast to take approximately 4.5 years. Each tunnel has two levels of lanes. One level allows for three 12-foot lanes for passenger vehicles. The other level, which carries two 12-foot lanes, is used for trucks and/or high occupancy vehicles. Figure 28 illustrates the tunnel cross-section.

Figure 28: I-710 Extension Cross Section



Source: Southern California Association of Governments

The I-710 tunnel uses open road tolling technology and transponders to collect tolls. With this technology, drivers affix a sticker to their windshield. Each time the car passes under a toll gantry, the toll is automatically deducted from a driver's prepaid account without the driver having to slow down. Vehicles without an electronic transponder are billed through video tolling based on license plate number.

The I-710 Extension has been extensively studied and has broad support from regional organizations. A version of the tunnel is included in the SCAG 2035 Financially Constrained RTP.

Toll Rate and Traffic Volumes

According to our analysis:

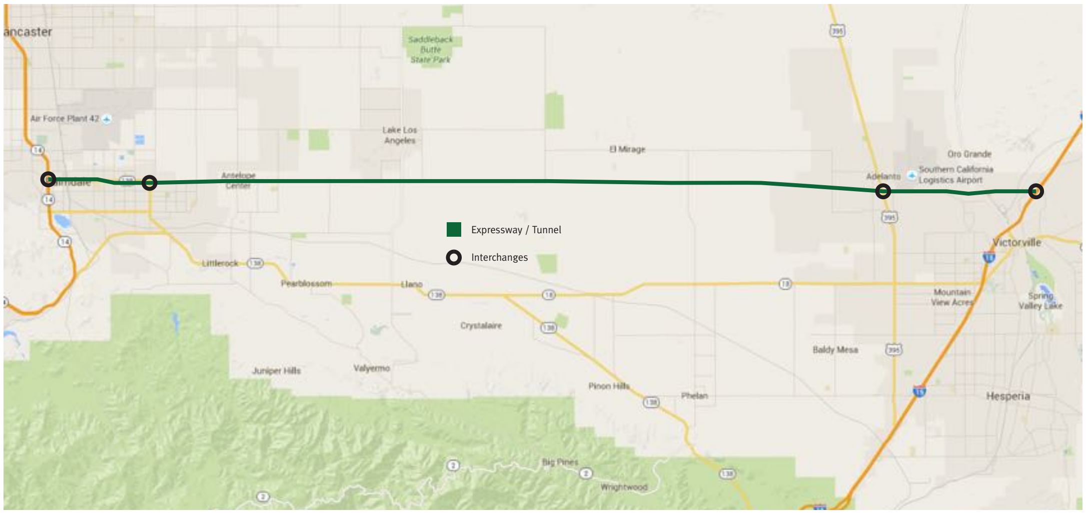
- The 2035 forecast of traffic on the I-710 Extension, with no toll and no trucks, is approximately 179,000 vehicles/day.
- The "maximum revenue" toll is about $3.00 (2015 $), yielding $273,000/day but would only be used by 91,000 vehicles, about 51% of capacity. This toll is lower than the rate suggested by earlier studies. However, since the regional network is quite dense, the road is relatively short and alternate paths for traffic exist. With a higher toll, traffic diversion could be an issue.
- At a $2.00 toll (2015 $) 2035 traffic is about 119,000 vehicles per day, 33% below the no-toll rates. A $2.00 toll (2015 $) efficiently balances traffic volume, capacity and revenues, yielding a volume/capacity ratio of 0.80-0.85, and daily revenues of $238,000.
- Any toll lower than $2.00 leads to significant congestion in the tunnel.
- The facility is forecast to slightly increase regional travel, by about 4.4%, but reduce regional travel time by about 33,000 hours. Traffic on major feeder routes (I-210 north, I-710 south and I-5 south) is forecast to increase, while traffic on major parallel routes will decrease.
- Increasing traffic for growth and tolls for inflation, the total toll revenue over 40 years (2015—2054) is about $7.7 billion.

Project 2: High Desert Corridor

The High Desert Corridor consists of a proposed 60-mile east-west surface expressway in North Los Angeles County between I-5 in Gorman and I-15 in Victorville. Models indicate that, over the next 25 years, only the 36.7-mile portion between SR 14 in Palmdale and I-15 in Victorville needs to be constructed. This report proposes creation of that eastern segment. There would be three value-priced toll lanes in each direction, with one lane per direction as a truck-only toll lane. The project would provide significant mobility benefits for the Lancaster-Palmdale area, projected to be the most rapidly growing portion of Los Angeles County through the year 2035. Currently, travelers between Lancaster-Palmdale and San Bernardino or Riverside Counties must use either SR 18 (not an expressway) or dip all the way down to I-210 and SR 14 in order to complete this trip.

This project has broad support from regional organizations. The entire corridor is included in the SCAG Financially Constrained RTP, with a completion date of the year 2030.[82] Figure 29 shows the study area for the High Desert Corridor project.

Figure 29: High Desert Corridor Study Area



As with the I-710 Gap Closure Tunnel, we propose this facility as consisting of value-priced toll lanes to ensure uncongested operations, maximize vehicle throughput and generate additional revenue to help offset the construction costs. Similar to all the projects discussed in this section, it would use All Electronic Tolling and would therefore not require toll booths or toll plazas.

Toll Rates and Traffic Volumes

According to our analysis:

- The 2035 forecast of traffic on the HDC traffic, with no toll, is about 93,144 vehicles per day.
- The "maximum revenue" average toll is about \$0.45/mile, (2015 \$) yielding \$798,917/day but using only 40% of the six-lane roadway capacity (note that most travelers will not use the entire corridor).
- At an average \$0.40/mile toll (2015 \$), 2035 traffic is forecast to be 53,985 vehicles per day, 42% below no-toll rates. This average toll balances slightly lower revenues (\$749,478/day) with higher traffic.
- A lower average toll (\$0.20/mile or less) is needed to increase the volume on the facility to Level of Service (LOS) C and D, but even the "no toll" option operates at LOS D. However, this toll would leave less room for traffic growth toward the end of the 40-year project life.

- The facility reduces total regional daily travel by about 53,000 VMT, or about 0.7% of facility volume). It would reduce regional travel time by about 98,000 hours. The HDC reduces travel on parallel routes, including I-210, but it also increases traffic on feeder routes, particularly I-15 to the northeast.
- Increasing traffic for growth and tolls for inflation, the total toll revenue over 40 years is for (2015–2054) is about $22.2 billion.

Project 3: Glendale-Palmdale Tunnel

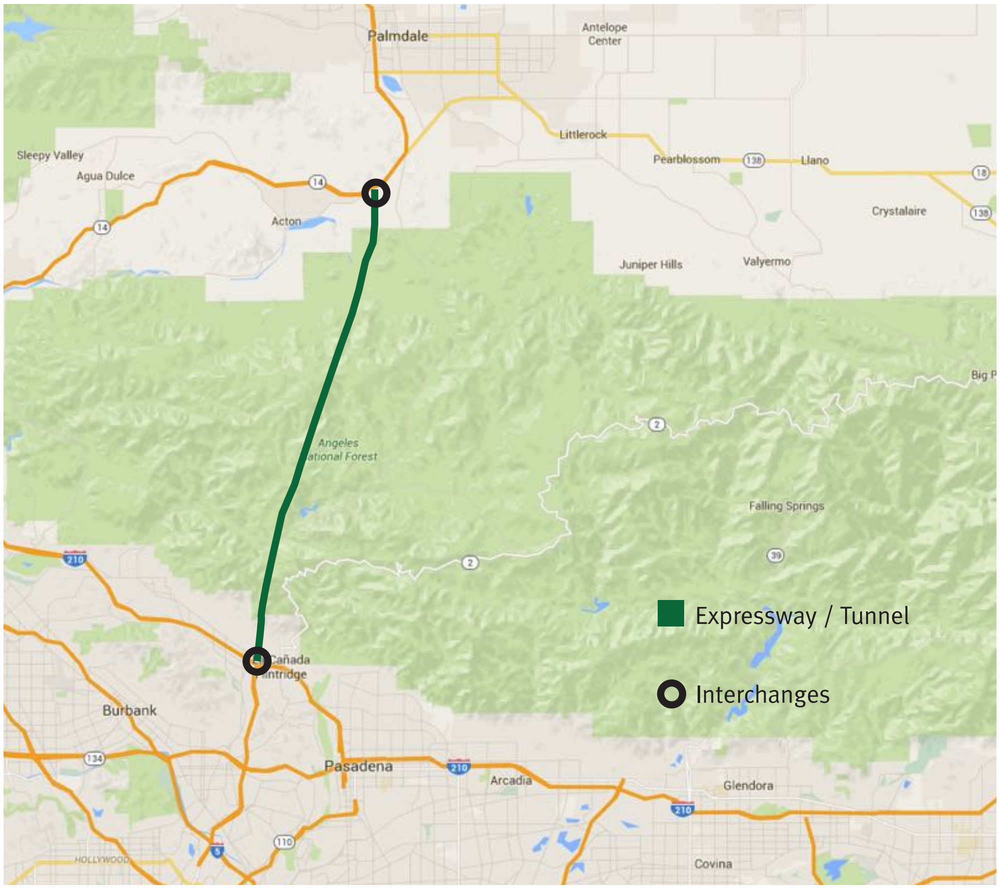
Significant population growth is expected in the Lancaster-Palmdale area of Los Angeles County through the year 2035. An additional north-south expressway corridor is needed to provide connectivity to the rapidly growing Lancaster-Palmdale area, to reduce traffic congestion on I-5 and SR 14, and to improve the viability of the Palmdale Airport as a reliever airport. Such a highway would reduce substantially the travel distance from many L.A. Basin locations to the Lancaster-Palmdale area (44% reduction from Pasadena, 27% reduction from Burbank, 34% reduction from downtown Los Angeles).

As noted in an earlier Reason Foundation study, the best possibility for such a corridor is a toll tunnel linking Palmdale with Glendale, deep-bored beneath the Angeles National Forest.[83] Relative to a surface alternative, a tunnel option costs less, has shallower grades thereby permitting higher speeds, and poses significantly fewer land-use and environmental impacts than a surface route.[84] Either alternative produces significant time-savings for many trips now made between Lancaster-Palmdale and the L.A. Basin, the San Fernando Valley and the San Gabriel Valley.

The toll tunnel/expressway extends north from SR 2 in the Glendale area to SR 14 six miles south of Palmdale. There are four value-priced toll lanes in each direction: three lanes for cars and light trucks, one lane for buses and heavy trucks. Heading northbound, most of the project is at a grade of 3 to 4%. The two primary segments are tunnels 4.7 miles and 10.8 miles long, with another five miles at-grade, for a total length of 21.2 miles.

Figure 30 shows the study area for this project.

Figure 30: Palmdale-Glendale Tunnel Study Area



The tunnel segments for this project consist of twin tubes created by tunnel-boring machines, with an inside diameter of 47 feet. Based on an approach used in France, the tunnel provides a total of eight lanes, six in one tube for light vehicles (cars and light trucks) in a double-deck configuration and two in the other tube for heavy trucks and buses.

However, current traffic conditions merit only a six-lane tunnel. We recommend building the six-lane light vehicle tunnel to provide congestion relief for most users as well as generate toll revenue. The parallel tube can be developed at a later date when traffic volumes justify more capacity. The lanes would be value priced to maintain free-flow speeds in the corridor during all times of the day.

The project is not part of the SCAG Financially Constrained RTP, but is included as an unfunded strategic plan project.

Toll Rates and Traffic Volumes

According to our analysis:

- The 2035 forecast of the 21.1-mile Glendale-Palmdale Tunnel (GPT) traffic, without a toll, is about 90,996 vehicles per day, operating at Level of Service D in the PM peak hour.
- The "maximum revenue" toll, $1.30/mile (2015 $), yields $1.06 million/day (2015 $) in 2035 but uses only 32% of the six-lane roadway capacity, which operates at Level of Service LOS A in the PM peak hour.
- At a lower toll, $0.90/mile (2015 $), the 2035 traffic is about 53,137/day, 42% below non-toll rates. The tunnel operates at LOS B in the PM peak hour. This toll yields slightly lower revenues ($1.0 million/day) with higher traffic and higher user benefits ($55.0B over 40 years).
- A lower toll ($0.70/mile or less) is needed to increase the volume on the facility to a LOS C level, but even with the "no toll" option, the facility operates at LOS D. However, a lower toll leaves less room for traffic growth near the end of the 40-year project life.
- The facility, at a $0.90/mile toll, reduces total regional daily travel by about 1,144,000 vehicle-miles, or about 0.2% of regional VMT. It reduces regional travel time by about 160,000 vehicle-hours (0.7% of regional VHT). The GPT is forecast to increase traffic on SR 2 near Glendale, and I-210 in northwest Los Angeles. Improvements being made to these expressways will allow them to handle this additional traffic.
- Increasing traffic for growth, and tolls for inflation, the total toll revenue over 40 years is $28.4 billion.

Project 4: Irvine-Corona Expressway

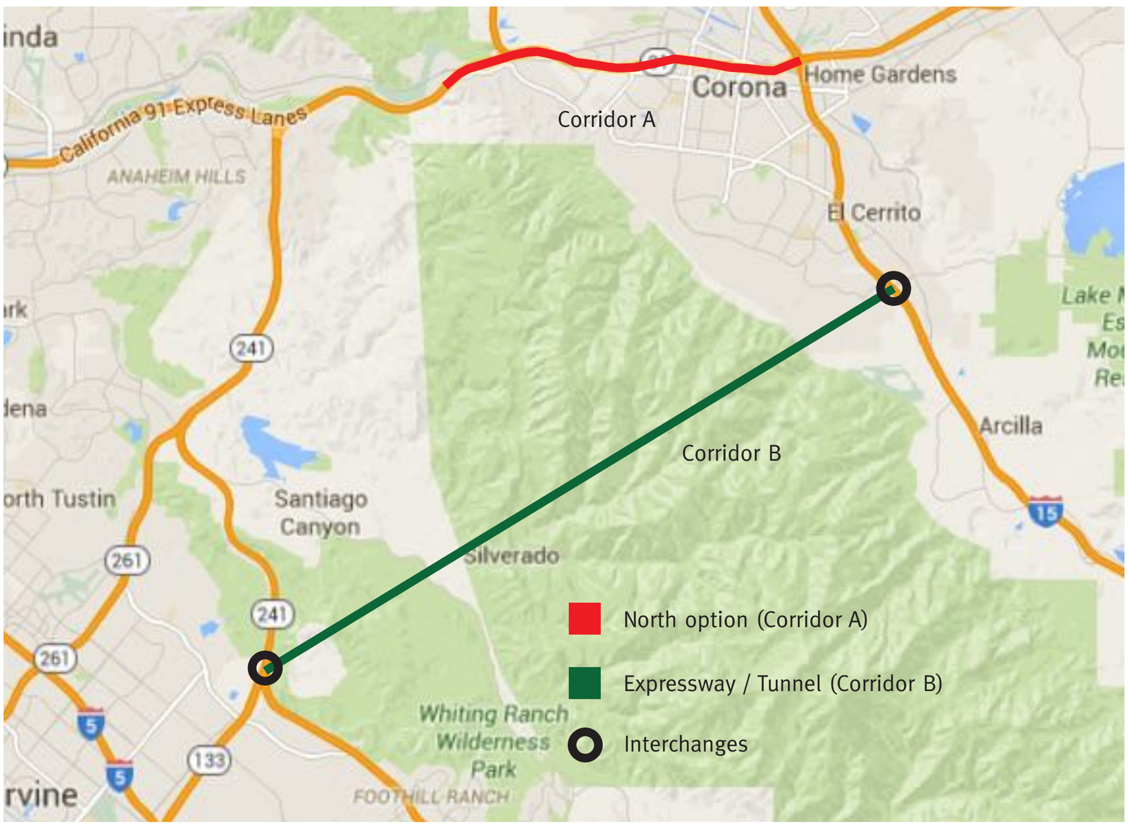
Continued population growth in Riverside County and continued employment growth in Orange County are forecast to strain the capacity of existing roadways between the two counties. There are currently only two primary roadways in use: SR 91 in the north and the narrow, two-lane SR 74 in the south. SR 91 carries over 95% of the daily traffic volume crossing the Orange/Riverside County line; it has one of the longest rush hours in the nation and is one of the most heavily congested expressway corridors in California.

SCAG has examined two projects intended to provide additional roadway capacity between the two counties:

- **North Alignment.** A new facility parallel to the existing SR 91, consisting of two elevated tolled lanes in each direction between SR 241 and I-15.
- **South Alignment.** A new, four-lane tolled facility (with two lanes in each direction) consisting of a tunnel connecting I-15 near Cajalco Road in Riverside County with SR 133 in Orange County.

Figure 31 shows the study area for these projects.

Figure 31: Riverside/Orange County Corridor Study Area



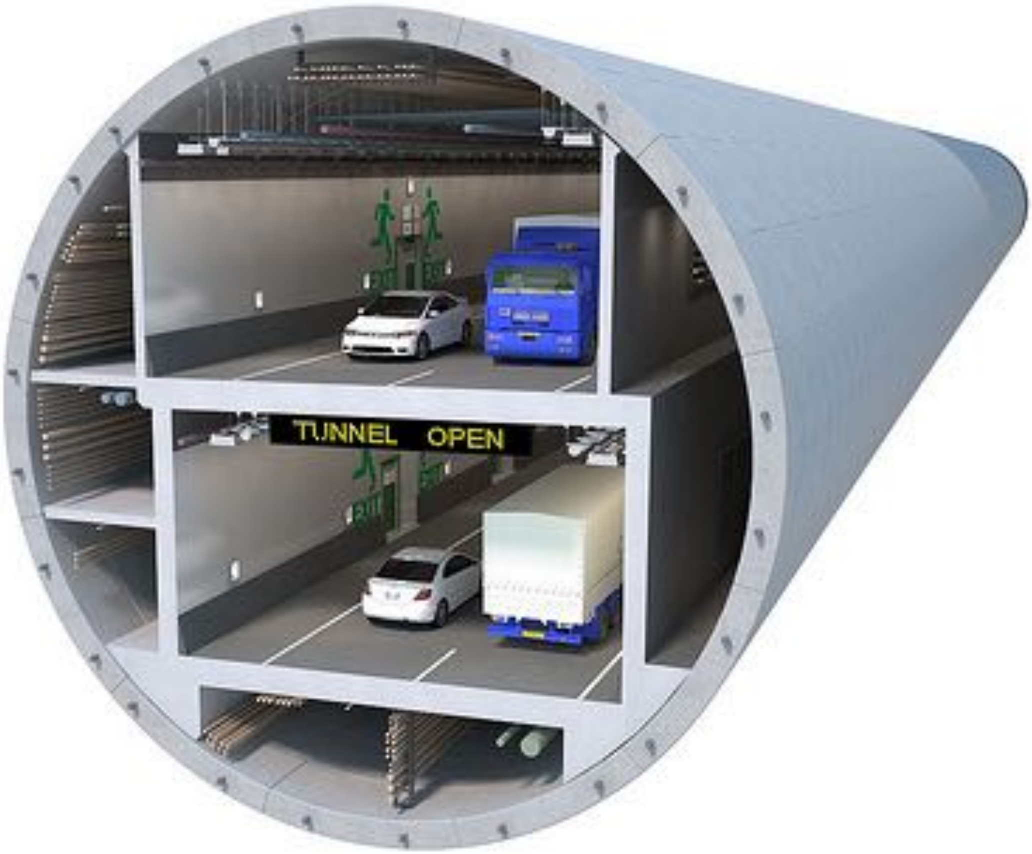
After analyzing both corridors, the south alignment (corridor B) is the better option, both from an overall network flow perspective and because much of the projected Orange County employment growth is expected to be in Irvine. The facility should be value priced to ensure uncongested operations, maximize vehicle throughput and generate additional revenue to help offset the construction costs.

The best tunnel option for this facility is two 48-foot diameter tubes, each 12 miles long, as part of a 14-mile total project length. The tube configuration is similar to the previously described Palmdale-Glendale Tunnel project.

Toll Rates and Traffic Volumes

For the Irvine-Corona Expressway (ICE), three sizes of the facility were evaluated: The four-lane section provided the best results. It is displayed in Figure 32 below.

Figure 32: Irvine-Corona Expressway Study Area



According to our analysis:

- In 2035 with no toll, the facility is forecast to carry about 85,944 vehicles per day, and operate at Level of Service (LOS) F in the PM peak hour. This volume is too high to be carried by a four-lane facility. Further, the volume is likely to increase beyond 2035.
- The "maximum revenue" toll, $0.70/mile (current $) for a four-lane facility, would carry about 48,200 vehicles/day in 2035 and yield about $404,880/day (current $) in 2035. A four-lane facility with a $0.70/mile toll would use about 60% of the roadway capacity and operate at LOS C in the PM peak hour. The facility would continue to divert enough traffic to maintain LOS D or better conditions through 2054.

- Any toll lower than $0.70 creates significant congestion on the facility.
- Any toll lower than $0.70 does not generate sufficient revenue.
- The facility is expected to reduce total regional daily travel by about 228,000 vehicle-miles, or about 0.04% of regional VMT. It is also expected to reduce regional travel time by about 66,000 vehicle-hours/day (0.3% of regional VHT). However, the ICE is expected to increase traffic on SR-241 and SR-133 (both toll facilities) near Irvine and on the Mid-County Parkway in Corona. Since these facilities are toll roads, they can use tolls to increase capacity if needed.
- The total nominal toll revenue for a $0.70/mile toll over 40 years (2015–2054) is about $11.7B.

Project 5: Cross Mountain Tunnel Expressway

There are three different tunnel concepts under consideration, all designed essentially for the same purpose: to provide another expressway connection between US 101 in the San Fernando Valley and I-10 in Central/West Los Angeles. The alternative concepts are as follows, going from west to east:

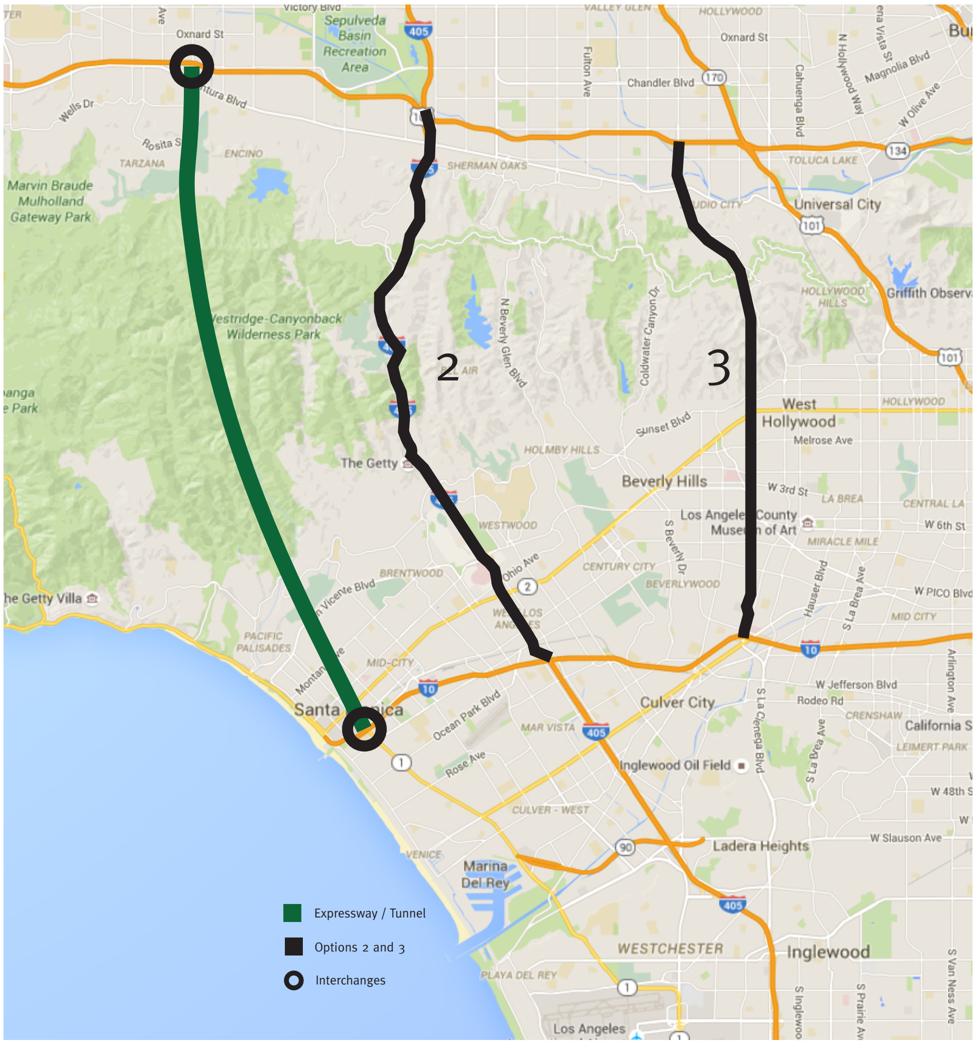
- Alternative #1 - Tunnel underneath Topanga State Park to the western end of I-10 (Tarzana – Santa Monica).
- Alternative #2 - Tunnel underneath the existing I-405 (Sherman Oaks – West Los Angeles).
- Alternative #3 - Tunnel underneath Laurel Canyon Blvd and La Cienega Blvd (Studio City – West Hollywood).

Any of the three alternatives, if implemented, would have a high traffic demand. Value pricing would be applied to ensure uncongested operations, maximize vehicle throughput and generate additional revenue to help offset the construction costs. From an overall network connectivity perspective, Alternative #1 (Tarzana – Santa Monica) is projected to provide the most benefit because it would provide a connection to/from the west San Fernando Valley. The other two alternatives more closely duplicate the geography of an existing expressway corridor. However, Alternative #1 is also the longest of the three, which will have cost implications.

The first two concepts are not part of the SCAG Financially Constrained RTP, but are included as unfunded strategic plan projects with no cost information provided. The third concept is not included in the SCAG RTP. Even as the highest price alternative, we recommend proceeding with Alternative #1, as the modeling shows the benefits significantly outweigh the costs.

Figure 33 shows the study area for these potential Cross Mountain Tunnel alignments.

Figure 33: Cross Mountain Tunnel Study Area



The Cross Mountain Tunnel would provide relief for three of the most congested freeways in the region (US 101, I-10, I-405). It would also provide relief for two of the top five most congested interchanges in the country (US 101 at I-405 and I-405 at I-10).

For this report, Alternative #1 was tested as a tunnel-surface facility using the alignment noted above. The facility connects US-101 in the north at Reseda Boulevard in Tarzana with I-10 in the south near 4th Street in Santa Monica. An interchange was added at Mulholland Drive, where the tunnel would feed into the surface links. This allows an additional entry-exit point for users of the facility, and provides an access point for construction and emergency vehicles into the middle of the facility and the interior tunnel portals.

Toll Rates and Traffic Volumes

For the Cross Mountain Tunnel (XMT), a six-lane facility was the only size analyzed.

According to our analysis:

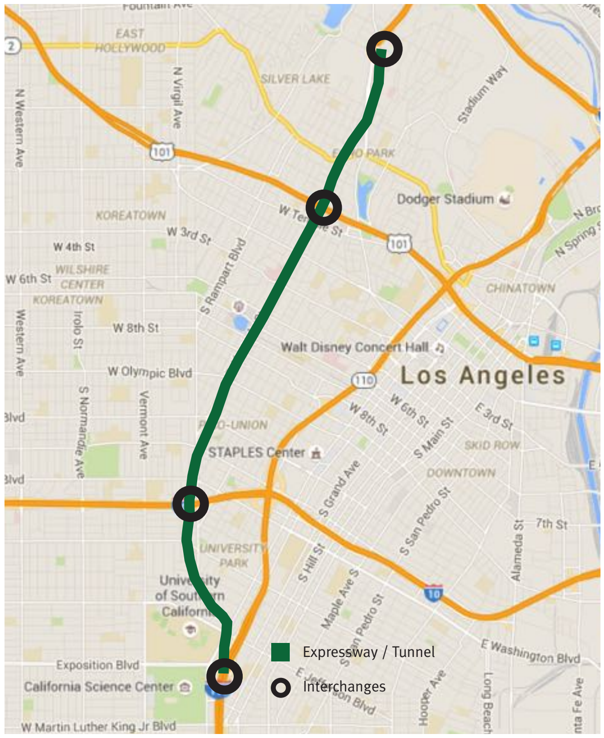
- In 2035 with no toll, a six-lane facility is forecast to carry about 109,000 vehicles per day, and operate at Level of Service (LOS) D in the PM peak hour.
- The "maximum revenue" toll of about $0.60/mile would carry about 51,300 vehicles/day in 2035 and yield $346,000/day (2015 $) in 2035. Such a toll would provide LOS B in the PM peak, leaving a great deal of unused capacity. The facility would continue to divert enough traffic to maintain LOS B conditions or better through 2054.
- A four-lane facility was analyzed, but over the long term it operated at LOS F and provided insufficient capacity.
- A six-lane facility with a toll lower than $0.60 does not generate sufficient revenue.
- The facility is forecast to reduce total regional daily travel by about 41,000 vehicle-miles, or about 0.01% of regional VMT. It is also forecast to reduce regional travel time by about 62,000 vehicle-hours/day (0.27% of regional VHT).
- The total gross toll revenue adjusted for inflation is about $9.7B.

Project 6: Downtown Bypass Tunnel

SR 2 currently transitions from an expressway to a surface arterial northwest of downtown Los Angeles, causing some traffic to divert onto Glendale Blvd and Alvarado St. The original freeway plan was to run the SR 2 expressway along what is now Santa Monica Blvd west to I-405.[85] This is no longer a viable option. However, another alternative, the Downtown Bypass Tunnel, would be a much shorter alignment through central Los Angeles to I-110 that would relieve highly congested expressways in the area including I-110, I-5 and US 101. Figure 34 shows the study area for the Downtown Bypass Tunnel project.

The project is not part of the SCAG Financially Constrained RTP, but is included as an unfunded strategic plan with full cost details provided in the index. We also recommend pricing the tunnel 24 hours a day to maintain free-flow speeds.

Figure 34: Downtown Bypass Tunnel Study Area



Toll Rates and Traffic Volumes

For the Downtown Bypass Tunnel (DBT), a six-lane facility with three lanes of traffic in each direction is adequate to carry the forecasted PM traffic and is the only size facility considered.

A six-lane facility appears adequate to meet the PM demand, as projected by SCAG demographic forecasts and traffic assignment modeling with a $ 1.00/mile toll. According to our analysis:

- In 2035 with no toll, a six-lane facility is forecast to carry about 151,000 vehicles per day, but would operate at Level of Service (LOS) F in the PM peak hour.
- A maximum revenue toll ($1.10/mile) and a toll of $1.00/mile provide similar LOS, similar revenues, and similar user benefits over 40 years.
- We used the $1.00/mile toll based on the lower cost to drivers. At a $1.00/mile toll (in 2015 $) traffic is about 93,000 vehicles/day in 2035 yielding revenue of $486,000/day. In 2035, the facility operates at LOS D in the PM peak hour with 74% of the capacity used. Such a toll also keeps traffic volumes low enough to maintain LOS D conditions or better through 2054.
- Any toll lower than $1.00 leads to congestion over the long term.

- The facility is forecast to increase regional daily travel slightly, by about 1,000 vehicle-miles, or about 0.0002% of regional VMT. However, it reduces regional travel time by about 48,000 vehicle-hours/day (0.21% of regional VHT).
- Increasing traffic for growth and tolls for inflation, the total toll revenue over 40 years (2015–2054) is about $13.6 B.

C. Project Combinations

Many proposed transportation projects have greater impacts when operating in combination than when considered individually. Conversely, sometimes project impacts can be offsetting rather than complementary. This section documents our analysis of potential traffic and user benefits for two combinations of the six previously assessed highway projects in the greater Los Angeles region:

- **Combination of Three Projects:** the I-710 Extension Tunnel (I-710T), the Glendale-Palmdale Tunnel (GPT) and the Downtown Bypass Tunnel (DBT).
- **Combination of All Six Projects:** the I-710T, the High Desert Corridor (HDC), the GPT, the Irvine-Corona Expressway (ICE), the Cross-Mountain Tunnel (XMT), and the DBT.

The three-project combination was selected on the geographical proximity of these projects to each other, and their complementary ability to relieve congestion. The six-project combination models all the projects operating as one system.

When operated in combination, whether as three or all six, the projects have cumulative effects that are greater than when operated individually:

- On average, facility use increases, percentage of capacity used in the PM peak increases, and facility level of service (LOS) decreases as congestion increases. The effect is particularly strong for the I-710 tunnel, which operates over capacity in 2035 if the other two projects are built. These LOS decreases can be significant and might require increases in facility capacity and/or increases in tolls in the later years to provide a LOS for which users would be willing to pay.
- The relative increase in impact is slightly greater for the three-combination group than for all six as a group, suggesting diminishing complementary impact for three projects. However, all six projects together still have substantial benefits. This does not mean that the three projects are less worthy (that depends on their costs versus benefits), but rather that their geographic locations do not produce much interaction with the initial three projects.

D. Project Summary

Table 21 provides a summary of the project details, benefits of individual projects and benefits of projects in combination.

Table 21: Summary of Project Details and Benefits

Project Details	I-710T	HDC	GPT	ICE	XMT	DBT	Total
Tunnel/Surface	Tunnel/ Surface	Surface	Tunnel	Tunnel	Tunnel/ Surface	Tunnel	
Toll for Best Use	$2.00	$0.40	$0.90	$0.70	$0.60	$1.00	
Type Toll	Flat	Per mile	Per mile	Per mile	Per Mile	Per Mile	
Tolling Length, Miles	5.7	36.7	21.2	12.4	11.3	5.2	92.5
Number of Lanes	8	6	6	4	6	6	
Tolling Length, Lane Miles	45.6	220.2	127.2	49.6	67.8	31.2	541.6
Projects by Themselves	I-710T	HDC	GPT	ICE	XMT	DBT	Total
2035 Daily Traffic at Toll	118,665	53,985	53,137	48,200	51,262	93,271	
2035 PM Level of Service	D	B	B	C	B	D	
2035 Percent Capacity Used, PM	75%	45%	44%	60%	39%	78%	
2035 Daily VMT at Toll	772,653	1,955,806	1,123,947	597,412	580,184	485,788	5,515,790
2035 Daily VHT at Toll	33,061	38,165	24,347	12,864	13,548	11,569	133,554
Daily VMT Saved	34,368	-52,977	-1,143,710	-228,022	-41,230	975	-1,430,596
Daily VHT Saved	-33,944	-98,075	-159,699	-66,361	-62,040	-48,382	-468,501
2035 Daily Toll Revenue	$237,239	$792,174	$1,011,552	$418,188	$348,110	$485,788	3,293,051
40-year Toll Revenue $2015B, no inflation	$6.08	$20.24	$25.90	$10.69	$8.88	$12.39	$84.18
40-year User Benefits (in billions), no growth	$10.74	$31.56	$55.01	$22.01	$19.99	$15.48	$154.79
40-Year Toll Revenue $2015B, 5% discount rate	$2.06	$7.02	$8.97	$3.70	$3.08	$4.29	$29.12
40-year User Benefits $2015B, 5% discount rate	$3.64	$10.96	$19.10	$7.64	$6.94	$5.38	$53.66
Projects in Combo 3	I-710T		GPT			DBT	
2035 Daily Traffic at Toll	170,941		57,139			96,772	
2035 PM Level of Service	F		B			D	
2035 Percent of Capacity Used, PM	107%		48%			81%	
2035 Daily VMT at Toll	970,451		1,208,791			504,002	2,683,244
2035 Daily VHT at Toll	31,293		26,516			12,292	70,101
Projects in Combo 6	I-710T	HDC	GPT	ICE	XMT	DBT	
2035 Daily Traffic at Toll	169,100	51,509	54,120	46,008	47,596	94,366	
2035 PM Level of Service	F	B	B	C	B	D	
2035 Percent of Capacity Used, PM	106%	43%	45%	58%	40%	79%	
2035 Daily VMT at Toll	959,999	1,889,909	1,144,934	570,248	538,689	491,474	5,595,253
2035 Daily VHT at Toll	30,586	36,617	24,856	12,147	12,538	11,819	128,563

1. Cost Estimates for Proposed Projects

Of the six projects being evaluated in this report, two (the I-710 Extension and the High Desert Corridor) are in the primary stages of planning and design. As a result, cost estimates from available reports can be used:

- **I-710T Extension:** Included in the 2008 and 2012 SCAG RTPs. The estimated project cost is $6.3 billion to construct four lanes in each direction, or eight lanes total ($1,117 million per mile or $139.6 million per lane-mile).[86]
- **High Desert Corridor:** Also included in the 2008 and 2012 SCAG RTP. The estimated project cost is $9.8 billion ($163 million per mile or $27.2 million per lane-mile).[87] This cost is significantly higher than earlier cost estimates, as site-specific factors and recent development have increased the cost.

For the other four projects, which are all tunnel projects, a range in cost from about $80 million to $300 million per lane-mile was identified based on peer research. An average construction cost estimate of about $150 million per lane-mile is used as a mid-range estimate.[88] This estimate is quite close to the per lane-mile cost estimate of the I-710 Tunnel, and is slightly higher because a portion of the I-710 extension is a surface facility as opposed to a tunnel. More-refined cost estimations of the proposed tunnel projects would need to be based on a thorough evaluation of site-specific factors including right-of-way restrictions, terrain, groundwater levels, soil and rock conditions, surrounding land use and local labor agreements.

Table 22 shows the cost estimates per project, and total overall, based on the discussion above.

Table 22: Reason Plan's Six Project Cost Estimates

Project	Length in Miles	No. of Lanes per Direction	Lane-Miles	Cost Per Lane-Mile	Cost Estimate (2015 $$)	Cost Estimate (YOE)
I-710 Extension	5.7	4	45.4	$139.6M	$6.3B	$10.7B
High Desert Corridor*	60.0	3	360.0	$27.2M	$9.8B	$16.6B
Glendale-Palmdale Tunnel	21.2	3	126.9	$150M	$19.0B	$32.2B
Irvine-Corona Expressway	12.4	2	49.6	$150M	$7.4B	$12.5B
Cross Mountain Tunnel	11.3	3	67.9	$150M	$10.2B	$17.3B
Downtown Bypass Tunnel	5.2	3	31.2	$150M	$4.7B	$8.0B
Total Capital Cost Estimate	**115.8**		**681.0**		**$57.4B**	**$97.2B**

* Note that only 37 miles of the 60-mile High Desert Corridor is tolled.
Source: Booz Allen Hamilton, Hartgen Group, Reason Foundation

For purposes of this section of the report, optimal tolls and facility sizes that were applied in the combination modeling runs were selected. There is a difference in project length and lane-miles of the High Desert Corridor (HDC) between the table above and previous tables because not all of the HDC project length is being tolled.

2. Financial Feasibility

Overall financial feasibility is based on the cost of building the project adjusted for inflation compared to the amount of toll revenue collected adjusted for inflation. Note that we take 15% of the toll revenue off the top to use for operations of the facility.

The estimated project cost for the express lanes is $97.2 billion, as shown in Table 22. This assumes a 40-year life-cycle. Table 23 shows the percentage of cost that is estimated to be covered by toll revenue.

Table 23: Reason's Plan's Six Projects: Percentage of Project Cost Covered by Toll Revenue over 40 Years

Project	Gross Project Revenue	Gross Revenue Less 15% for Operations	Project Cost Estimate	Percent of Project Cost Covered by Project Revenue
I-710 Extension	$7.7B	$6.5B	$10.7B	61%
High Desert Corridor	$25.6B	$21.7B	$16.6B	131%
Glendale-Palmdale Tunnel	$32.7B	$27.8B	$32.2B	86%
Irvine-Corona Expressway	$13.1B	$11.1B	$12.5B	89%
Cross Mountain Tunnel	$11.2B	$9.5B	$17.3B	55%
Downtown Bypass Tunnel	$15.7B	$13.3B	$8.0B	166%
Total Cost/Revenue	**$106.0B**	**$90.0B**	**$97.2B**	93%

As Table 23 shows, two of the six projects bring in more in toll revenue than they cost to build. The downtown bypass tunnel, due to the extreme congestion in the area, brings in $1.66 for every $1.00 it costs to build and operate. While the I-710 Extension and Cross Mountain Tunnel bring in 61% and 55% respectively in revenue compared to costs to build and operate, as a grouping the projects bring in 93% of their construction and operations costs.

Revenue of the toll expressways/tunnels was calculated in a similar manner to the express lanes and managed arterials. The gross revenue—or the total amount of toll revenue collected over 40 years—equals $106 billion for the six projects. We deducted 15% of the gross revenue to use for roadway operations and maintenance. The remaining 85%, or $90.0 billion, is the net revenue.

For the construction cost we use the 2.0% inflation rate to convert 2009's costs to 2015's costs. We then assumed that an equal amount of capital will be spent each year and adjusted each year's costs to inflation. The result is a construction cost of $97.2 billion based on year of expenditures.

These results leave us with a small hole of $7.2B. We recommend taking the remaining $7.2B from the surplus in the managed lanes funds. Many of the managed lanes connect to one of these six projects. These expressways/tunnels will substantially decrease travel times in the region and without these new projects, tolls on the managed lanes would need to be significantly higher for those lanes to operate at reliable travel speeds.

More details are available in Appendix D.

E. Tunnels

Due to the numerous mountain ranges, high suburban population density and heavy traffic congestion in Southern California, the region can benefit more than any other U.S. region from tunnel construction. Our report recommends building five tunnels to ease congestion. This section provides more details on the costs of tunnels, the advantages of tunnels, and other factors to consider.

Highway tunnels are fairly common in the U.S. More than 337 highway tunnels were in operation as of 2003.[89] New York City alone includes hundreds of miles of tunnels in the city and its vicinity for subways, highways, water systems, and railways. In Northern California, the Yerba Tunnel (1936) through Yerba Buena Island in San Francisco Bay in California was designed to be 540-ft long, 76-ft wide, and 50-ft high and it carries two decks of traffic.

In major cities and metropolitan areas across the nation, tunnels have emerged as a practical solution for transportation problems. Ironically, this was also true in the early 20th century, when high urban densities combined with low personal mobility jump-started major transit investments in subway tunnels in London (1863), Paris (1900), New York (1904), Tokyo (1927) and Moscow (1933). More recently, cities from Australia to Paris have re-evaluated the role tunnels could play in improving highway traffic circulation. Tunnels for highway use have been encouraged by dramatic efficiencies from improved design and tunnel-boring technologies. The ability to double stack lanes, for example, enabled the French transportation company Cofiroute to propose and build the A86 West missing link under Versailles.[90] Sydney, Australia was faced with similar problems as traffic slowed to a crawl. Building the Melbourne CityLink, a tolled mega-project that includes major elevated and tunnel projects through downtown Melbourne, Australia, helped reduce congestion.[91] New engineering designs and technologies allow for the construction and management of underground highway interchanges, dramatically improving the benefits of tunnels while minimizing above-ground disruptions to the urban environment.

The most important new technology is the tunnel-boring machine (TBM). (TBMs) are specialized machines used to excavate tunnels with a circular cross section. A popular alternative to drilling and blasting, TBMs do not produce surface disturbances and create a smoother tunnel wall. TBMs are typically assembled underground for a specific project and then disassembled and shipped to their next location. Figure 35 below shows a modern tunnel-boring machine.

Figure 35: Tunnel-Boring Machine

Source: ESA Images, http://www.esa.int/spaceinimages/Images/2012/04/Tunnel_boring_machine

Today's tunnels have an impressive array of air quality systems that allow the air inside of tunnels to be cleaner than that outside of tunnels. Air quality both inside and outside tunnels is controlled by the combination of tunnel ventilation systems and contaminant management technology.[92] Specific venting technology produces cleaner air inside the tunnel than at ground level outside the tunnel.

Modern tunnels have a number of safety features. Features once considered optional—such as cross passage emergency exits, fire suppression, and radio rebroadcasts—are now commonplace. One reason that tunnels are costlier to construct than surface roadways is that they are a far more comprehensive infrastructure system. Table 24 compares tunnel safety features by the decade.

Table 24: Tunnel Safety Features

Safety Feature	Before 1970	1970–1989	1990–1999	2000–2009	2010–2015
Cross Passage Emer. Exit, Pedest. Access	Yes: 3, 27% No: 3, 27% N/A: 5, 45%	Yes: 6, 60% No: 1, 10% N/A: 3, 30%	Yes: 6, 29% No: 1, 5% N/A: 14, 67%	Yes: 15, 44% No: 9, 26% N/A: 10, 29%	Yes: 9, 60% No: 0, 0% N/A: 6, 40%
Linear/Video Automatic Fire Detection	Yes: 5, 45% No: 0, 0% N/A: 6, 55%	Yes: 8, 80% No: 0, 0% N/A: 2, 20%	Yes: 5, 24% No: 1, 5% N/A: 14, 67%	Yes: 24, 71% No: 0, 0% N/A: 10, 29%	Yes: 10, 67% No: 0, 0% N/A: 5, 35%
Fixed Fire Suppression	Yes: 5, 45% No: 4, 36% N/A: 2, 18%	Yes: 1, 10% No: 3, 30% N/A: 6, 60%	Yes: 3, 14% No: 4, 19% N/A: 14, 67%	Yes: 22, 65% No: 1, 3% N/A: 11, 32%	Yes: 11, 73% No: 2, 13% N/A: 2, 13%
Smoke Control (Long/Transver)	Yes: 2, 18% No: 2, 18% N/A: 7, 64%	Yes: 8, 80% No: 0, 0% N/A: 2, 20%	Yes: 5, 24% No: 1, 5% N/A: 15, 71%	Yes: 24, 71% No: 0, 0% N/A: 10, 29%	Yes: 8, 53% No: 0, 0% N/A: 7, 47%
CCTV	Yes: 8, 73% No: 0, 0% N/A: 3, 27%	Yes: 7, 70% No: 2, 20% N/A: 1, 10%	Yes: 5, 24% No: 1, 5% N/A: 15, 71%	Yes: 13, 38% No: 0, 0% N/A: 21, 62%	Yes: 6, 40% No: 0, 0% N/A: 9, 60%
Radio Rebroadcast Emergency	Yes: 3, 27% No: 4, 36% N/A: 4, 36%	Yes: 7 70% No: 2, 20% N/A: 1, 10%	Yes: 5, 24% No: 1, 5% N/A: 15, 71%	Yes: 20, 59% No: 0, 0% N/A: 14, 41%	Yes: 7, 47% No: 0, 0% N/A: 8, 53%

Source: Review of Overseas Tunnels

Some regions build tunnels due to specific geographic features, such as the Hudson River west of New York City. A bigger concern in Southern California is seismic issues. Below is a letter detailing the safety of tunnels during the Loma Prieta quake of 1987 and the Northridge quake of 1994:[93]

Letter from Lindvall, Richter & Associates on Tunnel Seismic Issues:

> *We can state at the outset that deep tunnels are safer from damage during an earthquake than structures at or near the surface of the ground. Elevated transit structures could be the most hazardous because of the possibility of the trains falling off a column-supported guideway subjected to strong shaking. The reason that a deep tunnel is safer during earthquake shaking is that the tunnel is surrounded by a medium that is moving and moves along with it. At the ground surface, a ground/air interface exists and the shaking is more violent. Also, seismic surface waves are active, but they attenuate and de-amplify with depth.*

In a recent study titled "Damage to Rock Tunnels from Earthquake Shaking" by Dowding and Rozen),[94] the authors studied 41 tunnels where damage occurred and concluded that tunnels are less susceptible to damage from shaking than above-ground structures at the same intensity level. Kanai and others in Japan came to a similar conclusion in their paper titled "Comparative Studies of Earthquake Motions on the Ground and Underground.[95]

In Richter's book, *Elementary Seismology*, a similar phenomenon is reported from people in a deep cave when an earthquake struck; those in the cave were not aware of the quake while others at the ground surface were concerned for their safety.[96]

Another example is found in the 1973 National Oceanic and Atmospheric Administration (NOAA) report on the San Fernando earthquake of 1971. At the time of the earthquake, the San Fernando Tunnel of the Metropolitan Water District was being excavated. The earthquake caused the ground to warp up seven feet in a region that included the tunnel. However, the rails in the tunnel were not sufficiently distorted to cause a derailment, and the miners drove the locomotive out from the tunnel working area, a distance of three miles. Three other tunnels in the epicentral region did not suffer damage: the SP Railroad Tunnel (1876), the City of Los Angeles Aqueduct Tunnel (1913), and the MWD Newhall Tunnel (1968).[97]

We also note that neither the BART tunnel beneath San Francisco Bay nor the Los Angeles Red Line tunnel suffered any significant damage in the Loma Prieta Quake of 1987 and the Northridge quake of 1994, respectively.[98]

1. Tunnel Benefits

When Dwight Eisenhower first sketched out his proposed system of defense highways, the original network was supposed to bypass central cities. However, to build support and pass the legislation to authorize the Interstate Highway System, Congress changed parts of the plan. The end result routed expressways directly through downtown areas. Some regions further exacerbated the problem by routing expressways between White and African-American communities or between high and low-income communities. In some cases, such as Atlanta, an expressway curve that lengthened the highway was included to separate communities. In other cases expressways were placed through the heart of neighborhoods leading to urban displacement.

Few cities want an expressway dividing communities. However, most regions developed after World War II are oriented around the car and need additional expressway capacity to reduce congestion and enhance mobility. Tunnels can provide that capacity without harming area neighborhoods. For example, Washington State DOT is replacing the SR 99 expressway with a tunnel, in part to provide area communities better access to Puget Sound.

Clearly, tunnels have significant benefits. Elevated surface expressways can be dangerous during earthquakes. Tunnels, designed to move with the earth, are some of the safest structures in an earthquake. Most importantly tunnels can reduce congestion without displacing residents, harming the economy or changing the urban feel of the communities above them. In addition to the American cities detailed below, French engineers built a tunnel below Versailles to avoid infringing upon the historic site. The tunnel has eased access while protecting the national landmark.

2. Costs

A number of site-specific factors greatly influence the construction cost of any individual tunnel project, including right-of-way restrictions, terrain, groundwater levels, soil and rock conditions, surrounding land use and local labor agreements. These factors need to be assessed in a thorough, site-specific engineering feasibility study before construction or a final decision is made to commit public funds to the project. Thus, the following estimates represent a conceptual, sketch-level estimate of construction costs for the tunnels proposed in this report, based on an evaluation of costs associated with actual tunnel projects undertaken in other areas.

In December 2007, the Cascadia Center Discovery Institute based in Seattle, Washington sponsored an international tunnel symposium that featured tunnel examples prepared by the consulting firm Arup (Table 25 below).[99] These data are from eight actual roadway tunnels constructed in Paris, Zurich, Dublin, Madrid, Hamburg, Wuhan (China), Nanjing (China) and Shanghai.

Table 25: Overview of Selected Completed Tunnel Projects

Roadway	Length (miles)	Total Cost*	Cost/Lane Mile	Total Lanes	TBM Type
Paris A86 Highway	5.25	3,797	$120.5 M	6	All Terrain
Zurich Uetliberg	2.73	1,345	$131.1M	4	Boring Extender
Dublin Sea Point	3.5	1,432	$102.2M	4	Hard Rock
Madrid M30 South Bypass	2.2	710	$53.8M	6	EPB Shield
Hamburg Elbic River	1.9	956	$167.7M	3	Mixshield
Wuhan Yangtze River	2.24	298	$33.3M	4	Slurry
Nanjing Chang Jiang	3.7	525	$23.6M	6	Slurry
Shanghai Yangtze	15.8	1,992	$21.0M	6	Slurry

* All costs adjusted to current year (2015, USD in millions) numbers

Source: Data for this analysis can be found at Cascadia Center Discovery Institute, http://www.cascadiacenter.org

Internationally, tunnel construction costs vary considerably. The city of Wuhan in Hubei Province, China built its tunnel for the lowest amount on a cost per route-mile basis ($133 million per mile) while Paris paid the most ($723 million per mile). On a per *lane-mile* basis (cost adjusted for the number of lanes), Shanghai in Yangtze Province of China reported the lowest cost (at $21 million per lane-mile) while Hamburg paid the most ($168 million).

U.S. tunnel costs vary more than international costs. Over the last 30 years, two major tunnels have been constructed in the U.S. The difference in costs between the two projects shows the importance of proper management and a detailed understanding of the political process. Many errors could have been eliminated by better planning, better communication and better management, especially in pre-construction:

- **Central Artery/Tunnel in Boston, Massachusetts:** The Central Artery/Tunnel, or the "Big Dig," was a project consisting of two tunnels: a 3.5-mile long roadway tunnel (four lanes per direction, or eight lanes total) completed in 2006 that goes underneath downtown Boston, and the 1.6-mile (two lanes in each direction, four lanes total) Ted Williams Tunnel connecting Logan International Airport to South Boston. The total project would build 34.4 lane-miles of roadway and tunnel. In 1985, based on preliminary environmental impact studies, the project cost was estimated at $2.8 billion, or $6.0 billion when converted to year 2006 dollars.[100] When the Big Dig was completed, the actual project cost was $14.6 billion ($2.8 billion per mile, or $424 million per lane-mile). The Ted Williams Tunnel alone cost $1.9 billion, or $296.9 million per lane-mile. The reasons for project cost escalation can be summarized as follows: errors and omissions during the design process, additional costs added for environmental mitigation, scope growth such as new interchanges, and inflation due to delays in construction.[101]

- **Port of Miami Tunnel, Miami, Florida:** The Port of Miami Tunnel was designed to provide a connection for trucks between the Port of Miami and I-395. It is used exclusively by trucks. The full project included building the 0.75-mile, four-lane tunnel, improving the roadway on Dodge and Watson Islands and widening the I-395 MacArthur Causeway bridge.[102] The final cost was $669 million or $223 million per lane-mile, which is about half the cost of the Central Artery/Tunnel, or "Big Dig."

Figure 36: Ted Williams Tunnel, Boston

Figure 37: Port of Miami Tunnel

One of the major differences between the two is the delivery method. The Central Artery/Tunnel was built under a design/bid/build process where separate companies handled the design and the build components. This increased the cost, the risk and the construction time of the project. The Port of Miami Tunnel was built under a P3 concession where a single private party builds and maintains all aspects of the facility. P3s decrease risk, cost and the time required to build the project. The following chapter provides more details on reducing the risks in mega-projects.

Part 8

Reducing the Risks of Tolled Mega-Projects

Building out Southern California's express lanes network and converting HOV lanes to express lanes will cost approximately $108.8 billion adjusted for inflation. Developing the managed arterial network for buses and building the six recommended expressways/tunnels will also use limited resources. Southern California transportation entities have sufficient revenue to build this transportation system without raising taxes, but doing so cost-effectively requires using long-term toll concession public-private partnerships.

A. The Role of Public Private Partnerships

Entering into long-term concession public-private partnerships (P3s) to build these projects reduces taxpayer costs and shifts risk to the private sector. While new projects in some metro areas have struggled because of insufficient early traffic volumes, P3s shift the risk of insufficient traffic and revenue from taxpayers to investors. The congested conditions on Southern California expressways have already led to three of the most heavily used express toll lanes in the country—on SR 91 in Orange County and on I-10 and I-110 in Los Angeles County.

Along with Colorado, Florida, Texas and Virginia, California has experience with the long-term toll concession model.[103] Under this approach, the private partner takes major responsibility for financing the project, investing equity for perhaps one-quarter of the project cost and financing the balance based on the projected toll revenues. The concession company takes long-term ownership responsibility for a defined period of years (e.g., 35 to 50 years), during which it must build, operate, manage and maintain the toll road or toll lanes at its own risk.

Contrast long-term concessions with building and operating a facility through availability payments or design-build methods. While availability payments are a type of P3 that include risk-transfer, they use public sector funding from gas taxes, tolls, general funds or other revenue, which leads to two problems. First, the private party has no incentive to keep costs down since it is not providing the funding. Second, the users-pay users-benefit rationale is reduced since availability payments include gas taxes (which is a weaker user fee) and general fund revenues (which is not a user fee at all). Design-build shifts some risks, including cost overruns, to the private partner. But it does not shift traffic and revenue risk, nor does it ensure that the initial design is optimized for lowest life-cycle cost.

Limiting the state's risk by shifting much of that risk to the private-sector partner is the biggest advantage of toll concessions.[104] The Express Toll Network, whether built as a single project or a series of projects, meets the definition of being a "mega-project." The two major risks frequently seen with such projects are inaccurate forecasts, leading to cost overruns and traffic/revenue shortfalls.[105]

Recent reports by two of the leading bond rating agencies, Fitch and Standard & Poor's, point to a tendency of such forecasts to be overly optimistic, which puts the bondholders at risk.[106] Several recent toll roads, in which the private sector developed the project but did not take on ownership-type risk, have all experienced serious shortfalls in early-years' traffic and revenue: Colorado's Northwest Parkway, South Carolina's Southern Connector and Virginia's Pocahontas Parkway. While Southern California is less prone to shortfalls in traffic and revenue than smaller metro areas, risk can never be completely avoided.

Minimizing life-cycle costs is another advantage of the long-term toll concession approach. If the same enterprise that is designing and building the toll road also must operate it profitably for 50 years, it has every incentive to build it right in the first place, rather than cutting corners to get the initial cost down. Spending an extra 10 to 15% on a more durable pavement in the first instance generally pays for itself several times over in lower ongoing maintenance costs during the roadway's lifetime. But neither traditional public-sector project development nor the design-build model is able to internalize this incentive effect, since operating and maintenance costs are not the responsibility of the entity designing and building the roadway in those models.

Cost-sharing is possible under a concession agreement for those projects that cannot be fully supported by toll revenue financing. For example, in such cases the public sector (e.g., Caltrans, L.A. Metro, OCTA) would make an "equity" investment for 20–30% of the project cost, with the balance being financed out of toll revenues, and the responsibility to collect and manage these toll revenues falling to the concessionaire. In most cases, with this type of mixed funding, the concession company agrees to share toll revenue above a certain level with the state agency. This type of mixed financing is being used currently for several mega-projects in Texas (with Texas DOT and/or local Regional Mobility Agencies analogous to CalTrans and OCTA).[107]

Regardless of the type of P3, government still has an active oversight role. P3s have very specific terms on project length, pavement quality, and operating characteristics. Government monitors the concessionaire to ensure it is adhering to all parts of the contract. If the concessionaire does not adhere to all conditions in the agreement, penalties up to termination of the lease can occur. As a result, the concessionaire has a strong incentive to provide good customer service. Some P3 projects have generated controversy. The following points debunk some of the most controversial P3 practices.

- **Highway and transit projects developed by international companies increase the number of Californians employed in the construction industry.** P3 experiences in the U.S. show that international companies hire mostly U.S. workers. Transportation projects need construction workers, and workers in Spain cannot build a construction project in California. As P3s provide almost 50% of the resources for large projects, they increase local employment in the construction sector by 40%.[108] Other countries have many companies with decades of experience in P3s because those countries do not have a dedicated gasoline tax to build infrastructure. With increasing fuel efficiency of motor vehicles, the revenues produced by per-gallon gas taxes are declining, so we need to look more to toll-financed projects. U.S. engineering companies such as Parsons Brinckerhoff and HNTB Corporation are also involved in P3s. U.S.-based investment firms such as Morgan Stanley and JPMorgan Chase are creating their own infrastructure funds to invest in PPPs. Many city- and state-owned pension funds are also investing in P3s, including CalPERS and CalSTRS.
- **PPPs do not commit future generations any more than lottery, union or other state contracts.** State governments regularly make commitments that affect taxpayers for longer than 50 years. Bonding for infrastructure and changing public employee pension benefits are two examples. Because the capital costs for major infrastructure projects are so high, it is good policy to finance them over long periods of time, so that people can enjoy their benefits while paying for them as they use them. And PPP documents are flexible. All concession agreements have detailed provisions to permit changes during their term. These provisions deal with such matters as negotiating and arbitrating disputes and employing independent parties to make fair financial estimates. Typically, the only limit to changes to the concession is that neither side be financially disadvantaged by the changes. With long-term commitments come long-term benefits. In the absence of sufficient conventional transportation funding, using P3s to deliver new transportation infrastructure enhances the mobility of current and future generations and benefits the economy over the long term.
- **Today's P3 deals do not include rigid non-compete clauses that prevent state and local officials from building nearby competing roads.** While some early projects (including the original SR 91 Express Lanes) had such clauses, today's

concession agreements would allow California transportation agencies to build everything in their current long-range transportation plans, regardless of any impact on the P3 project's traffic and revenue. Political challenges and limited funding make it very difficult for Caltrans to build new non-tolled lanes in Southern California. If new lanes were built, today's P3 agreements would likely spell out a revenue-sharing formula for some portion of toll revenue.

- **Government is protected if the private party in a P3 goes bankrupt.** In the event of a bankruptcy filing by the concession company, the asset reverts back to the project lenders who, with permission from the state, would select a new operator. If the concessionaire is in ongoing violation of key provisions of the concession agreement, the ultimate remedy is for the agreement to be terminated, with the state receiving the highway for free. The lenders have strong financial incentives to continue to properly operate and maintain the road, since they risk losing the value of their investment. The state must approve any contract changes.

Part 9

A Transit Network for the 21st Century

Southern California has one of the most extensive transit networks in the U.S. Interestingly, transit ridership declined slightly from 56 trips per capita in 1985 to 51 trips per capita in 2008 even while the percentage of commuters using transit increased from 5.1% to 6.2% over roughly the same time period.[109] What explains this discrepancy in numbers? Southern California has added significant transit service over the last 30 years, so people who did not previously have access to transit can use it today, but operators have increased headways (time between transit vehicles) on certain lines. So while transit is moving more people, each rider is taking fewer trips. This part will explain how the region can increase its transit ridership per capita. First, it will examine the most effective type of transit for Southern California. Then, it will detail the region's current system. Finally, it will explore how the region can cost-effectively modify its current system to provide a more ideal transit experience.

A. Transit in Post-World War II Metropolitan Regions

Substantial research has been conducted into the best way to operate transit service in different regions. Geographical orientation of service is one key aspect. Several studies conducted over the past decade have shown that multi-destination transit networks (grid networks) are most efficient in attracting passengers and are cheaper to operate than downtown-based systems (radial networks).

In 2008, Gregory Thompson, chair of the Transportation Research Board Light Rail Committee, and Jeffrey Brown, associate professor of transportation planning at Florida State University, studied 45 U.S. metro areas to determine whether radial or grid networks offer better service.[110] The authors also separated metro areas into those that have bus service only and those that have both rail and bus service. They found that the grid or multi-destination areas that used both rail and bus transit performed better. The radial approach connected neighborhoods to the central business district (CBD), but made reaching jobs outside of the CBD difficult. The multi-destination approach, while not as good at connecting neighborhoods to the CBD, was much better overall because it offered reliable transit service to more parts of the metro areas. Further, from 1984 through 2004, the grid metro areas experienced much smaller productivity declines (single digit) than the radial metros (25%). (Productivity refers to the number of people using the transit system compared to the cost to operate that service.) There was also a smaller increase in per-capita costs for the grid service compared with the radial service.

Thompson and Brown studied two bus-only systems in more detail. Broward County Transit (BCT) in Fort Lauderdale, Florida, and the T in Tarrant County, Texas (Fort Worth), both cover similarly sized areas with similar growth patterns. While the T has a radial pattern, BCT has a grid focus. BCT had 31.72 boardings per hour, which was almost double the T's 16.45. Operating expenses for BCT were also substantially lower, while load factor—the percentage of seats and standing room occupied on a transit vehicle—was substantially higher.

Figure 38 shows the difference between Broward County's grid service on the left and Tarrant County's radial service on the right.

Figure 38: Transit and Employment Access
Broward County, FL and Tarrant County, TX

Source: Jeffrey Brown and Gregory Thompson, *Hubs, Spokes, the Grid, and the Future of Transit*

That study also highlights the differences between pre-World War II metro areas and post-World War II metro areas. New York, Chicago and several other major northeastern metro areas experienced their fastest period of growth before World War II. Pre-World War II metro areas developed around walking and rail. They have higher population densities and are typically more compact and more centralized. Los Angeles, Dallas, Phoenix, Miami and other southern and western metro areas experienced their fastest growth after World War II. These metro areas developed around the automobile. They have lower population densities and occupy a larger geographic area. These post-World War II metro areas are all multi-centric rather than mono-centric—i.e., they do not have a single "central business district" but have numerous business districts dotted across the metro area.

Some post-World War II cities, such as Portland, have tried to duplicate the characteristics of pre-World War II cities using urban growth boundaries. Such boundaries limit the physical area of development, creating denser communities. The downside is they also drive up housing costs.[111] Moreover, such boundaries have in fact had minimal success in increasing transit usage. Portland's transit usage is not much higher than that of Denver or Salt Lake City or San Diego—comparable cities with less-stringent land-use restrictions. Portland's usage is far lower than Los Angeles' usage. It is unlikely that Los Angeles could successfully engineer transit-supporting densities through regulation.

Another challenge is the prevalence of traditional Euclidean zoning, separating residential and commercial uses.[112] This additional factor further limits the effectiveness of rail. And while mixed-use zoning has become popular in L.A.'s urban core, the majority of Southern California is still zoned into traditional residential, commercial and industrial areas, and considerable opposition exists to changing traditional zoning. Furthermore, while some residents are content to pay higher housing prices to live in a denser area with more transit options, most residents still prefer a location in the suburbs. The upshot is that regardless of policy, Los Angeles could build a transit network similar to New York City and still have much less ridership. Instead, the region should build a transit system around its existing density and land use pattern. And while such a network will improve the region's transit system, Southern California will never have the transit ridership of New York City.

What does this mean for Southern California's transit system? For one thing, it suggests that the basic grid-type bus service already in place should remain the predominant pattern for transit, to serve this multi-centric metro area. For the same reason, we should be skeptical of expensive new rail projects and further expansions of heavy rail, light rail and commuter rail.

As of 2007 Los Angeles Metro had 495 million unlinked transit passenger trips.[113] Approximately 83% of those trips were by bus while only 17% were by heavy rail or light rail. Despite recent rail expansion, bus riders remain the vast majority of transit passengers.

However, according to SCAG, Southern California plans to spend $81 billion to add additional rail transit lines between now and 2040.[114] A total of $11.8 billion is for expanding the heavy rail purple line. A total of $16.9 billion is for expansion and construction of various light rail lines. Another $4.1 billion is for extension of the Metrolink Perris Valley Line to San Jacinto and Temecula. (Another $47.7 billion is for high-speed rail from Los Angeles to San Diego and from Los Angeles to the Antelope Valley, but since this intercity rail is not transit, we will disregard it in this discussion.). Overall, the region is planning to spend $33 billion on rail transit expansion. Further, $31 billion (94%) of these rail transit funds go to just one county—Los Angeles. The region also plans to spend $139.3 billion on transit maintenance, much of that dedicated to supporting rail and rail-related improvements. But in contrast, just $21.7 billion is dedicated to increasing bus transit service (including the initial purchase of vehicles) in all six SCAG counties, with $4.6 billion of this dedicated to bus rapid transit. While some of the existing maintenance funding supports bus services, most of the funds support inefficient rail expansions.

These plans suggest that Southern California is spending resources not for current riders but in the hopes of attracting new riders. These rail expansion plans will do little or nothing for most current riders; L.A. Metro has actually reduced bus service to pay for some rail expansions. The cutbacks in bus service may violate a court-ordered consent decree that requires Los Angeles Metro to provide sufficient bus service at reasonable prices.[115]

This report accepts the need to maintain existing rail lines and to complete lines currently under construction. But it considers any further heavy, light, and commuter rail expansion as an ineffective, cost-prohibitive method of increasing transit ridership. The major focus should instead be on attracting more people to an expanded and higher-performing bus system.

Of course, the traditional problem with buses is that traffic congestion has an impact on bus travel times and severely impacts transit's time competitiveness with the automobile. Since buses travel in the same traffic lanes as cars, automobile drivers can travel the same route in less time than bus users (avoiding the need to stop at bus stops), thus substantially diminishing time-related incentives to use transit as an alternative. Fortunately, express bus service and bus rapid transit can take advantage of toll-free access to the express lanes and managed arterials outlined earlier in this report. This allows for fast, reliable travel times and, in so doing, can significantly change commuters' cost-benefit calculations—shifting the balance toward transit, without ever penalizing motorists.

Below we outline a new approach to transit based on establishing a comprehensive network of express bus, bus rapid transit, limited-stop bus and local bus service across the Southern California metropolitan area. The proposal would replace some planned rail lines with express bus and bus rapid transit. The great advantage of a bus-based transit system of this sort is that for the cost of three new rail lines, serving just a handful of commuter corridors, Southern California can create a comprehensive transit system for *the entire metro area.* What's more, this comprehensive system could be implemented over the plan's lifetime—decades before a rail network would be completed.

Figure 39: New Express Bus and Managed Arterial Bus Lanes

B. The Characteristics of Express Bus and Bus Rapid Transit

High-quality limited-stop bus services typically operate as express bus on expressway and other high-speed arterials, and as bus rapid transit on arterials and local streets. There are differences between these two types of services.

Express bus is a point-to-point bus service from one of many park-and-ride lots in the suburbs to various business districts throughout the metro area.[116] Metro areas have several different bus routes serving a park-and-ride area or have intermediate stops where commuters can transfer from one bus to another. Express bus service is used mostly during peak periods when choice ridership is higher. Express bus mainly operates on expressways or primary arterials, making its service characteristics similar to commuter rail.

Bus rapid transit (BRT) is an enhanced bus service that operates with characteristics of a dedicated guideway.[117] As a result BRT operates at faster speeds, provides greater service reliability and increased customer convenience.[118] BRT operates mainly on arterials, has frequent stops along the transit line (every 1⁄4 to 1⁄2 mile) and serves multiple origin and destination pairs. Its service characteristics are similar to heavy or light rail.

To more effectively differentiate from local bus, BRT often has the following features:[119]

- Running ways that give buses priority
- Unique station design
- Larger vehicles
- Electronic smart card/off-board fare collection
- Intelligent transportation systems such as priority signaling
- More frequent service especially during rush hour
- Specific branding

Since BRT runs on arterial and local streets, it may have additional features to help it fit into the community. These include land use or area-specific zoning and elevated boarding platforms level with the station.

C. BRT-Heavy, BRT-Lite and Virtual Exclusive Busways

Since the term BRT has come to encompass a considerable range of service types, a recent research report from the Federal Transit Administration sought to provide some clarity by separating BRT into two basic types:[120]

- "BRT-heavy" refers to BRT systems that operate in dedicated rights of way
- "BRT-lite" refers to BRT systems that lack dedicated rights of way. Such services have many of the components of BRT-heavy but use fewer enhancements. These services may be as basic as limited-stop arterial express service with signal priority.

Our basic premise—that express bus and BRT can produce more transit bang for the buck in Southern California—is generally valid. However, dedicating a full lane to bus service has drawbacks.

In the 1970s various state DOTs experimented by dedicating an expressway lane in each direction to express bus service. Most of these lanes operated well under capacity. This fact led to the conversion of original transitways for express bus service, such as the Shirley Highway in Northern Virginia, to HOV (high occupancy vehicle) lanes.[121] Initially, vanpools were allowed in, and when that measure failed to use all the capacity, three-person carpools were permitted. In most metro areas that took this path, the eventual result (as on I-110 in Los Angeles) was HOV lanes filled with two-person carpools. Unlimited numbers of HOV-2s led to congestion, greatly reducing the "express" nature of the bus service.

This is precisely where priced lanes (such as our proposed express lane network) can make a significant difference. Variable pricing can keep such lanes flowing at a high volume with no congestion (at LOS C). Therefore, a properly run priced lane can provide express buses with performance comparable to what they get from an exclusive busway. Because of this, some have termed a priced lane that provides guaranteed access for express bus/BRT service a "virtual exclusive busway" (VEB).[122]

VEBs have already been implemented in Southern California. Los Angeles Metro's express bus service in the express lanes on I-10 and I-110 is an example of a VEB. I-10 and I-110 are dynamically priced lanes which provide free passage to buses, vanpools and emergency vehicles but charge a variable toll based on congestion to automobiles.

While the I-10 and I-110 express lane conversions were funded by a congestion reduction grant from USDOT, there are several other ways to fund HOV to HOT conversions and new HOT lane construction. In some metro areas the DOT and transit operator enter into an agreement to build and operate the express lanes together. Texas DOT and Houston Metro's transit agency have an agreement to operate service on Houston's Katy Freeway (I-10).[123] The $250 million project added four priced lanes to the median of the expressway, replacing a single reversible HOT lane as part of a larger-scale project that rebuilt and widened the roadway. It is a public-public partnership between Harris County Toll Road Authority (HCTRA), the local transit agency (Metro) and the Texas DOT, with the approval of FHWA and FTA. HCTRA financed the priced lanes and will operate and maintain them, using the toll revenue for debt service and operation and maintenance costs. Metro is guaranteed up to 25% of the priced lanes' capacity, for any combination of buses, vanpools and carpools. In a memorandum of understanding (MOU), it agreed to increase the HOV occupancy level over time, as needed, to stay within its 25% usage. HCTRA, in turn, agreed in the MOU to use variable pricing to maintain LOS C conditions, thereby limiting the number of toll-paying vehicles using the priced lanes.

The same "empty lanes" phenomenon present in expressway HOV lanes also occurs on bus-only roadways and bus-only lanes on arterials. These lanes, exemplified by the Metro Orange and Silver Lines, have two significant drawbacks. First, obtaining an exclusive right of way is expensive, in both land costs and pavement costs. Second, since very few corridors can support more than 10 such buses per hour (one every six minutes) and usually only during peak periods, for the vast majority of the time that expensive right of way is empty and unproductive. Even with one-minute headways (60 buses per hour), an exclusive bus lane could handle at least 1,600 vehicles per hour at uncongested LOS C conditions. Thus, 1,540 spaces are going to waste every hour if that lane is used exclusively for bus service. Table 26 examines the person-throughput of the corridor with various levels of bus service.

Table 26: Hourly Directional Throughput Comparison for Constant LOS E							
Transit Percentage (person trips)	GP Lanes Vehicle Capacity (vph)	Cars per Hour	Auto Throughput (persons per hour @ 1.15 persons per vehicle)	Transit Throughput (persons per hour)	Required Buses per Hour (40 person capacity)	Total Vehicles per Hour	Total Throughput (persons per hour)
0%	1,870	1,870	2,151	0	0	1,870	2,151
2%	1,870	1,870	2,151	43	2	1,872	2,194
4%	1,870	1,870	2,151	89	3	1,873	2,240
5%	1,870	1,870	2,151	113	3	1,873	2,264
10%	1,870	1,870	2,151	238	6	1,876	2,389
15%	1,870	1,870	2,151	380	10	1,880	2,531
20%	1,870	1,870	2,151	536	14	1,884	2,687
25%	1,870	1,870	2,151	715	18	1,888	2,866
30%	1,870	1,870	2,151	920	23	1,893	3,071
32%	1,870	1,870	2,151	1,010	26	1,896	3,161
33%	1,870	1,870	2,151	1,059	27	1,897	3,210
34%	1,870	1,870	2,151	1,107	28	1,898	3,258

Examining Table 26, we can see that unless transit usage in the corridor rises to 34%—far higher than is likely—converting two general purpose lanes to bus-only results in either a degraded level of service (i.e., severe LOS F conditions for the GP lanes) or a reduced throughput capacity (last column of Table 26). Neither of these conditions is a good outcome for increasing mobility. Managed lanes maximize throughput for both automobiles and buses.

The managed arterial maximizes throughput for both cars and buses. It avoids prioritizing one mode over the other. Buses using the underpasses for no charge will have more predictable schedules, increasing passenger use.

Table 27 compares the trade-offs in four alternatives for improving bus performance:

Table 27: Alternatives for Arterial Bus Rapid Transit Improvements				
	Restriping	Convert GP	Add Lanes	Managed Arterial
Right of way cost	None	None	High	Low
Construction cost	Low	Low	High	Very high
Reduced left turns	Yes	Yes	Yes	Yes
Impact on auto throughput	Minor, negative	Major, negative	Minor, positive	Major, positive
Under-utilized bus lane(s)	Yes	Yes	Yes	No
Impact on congestion	Minor, negative	Major, negative	Minor, positive	Major, positive
Safety impact	Significant, negative	Some, negative	Minor, positive	Minor, positive
Revenue generation	No	No	No	Yes, significant

Each of the alternatives in Table 27 involves trade-offs. All four would restrict left turns, to avoid holding up buses operating in the inner lane(s). All but the managed arterial would use only a small fraction of the bus lanes' capacity. And the restriping alternative would eliminate the median, with buses operating directly adjacent to traffic going in the opposite direction. All things considered, we conclude that the managed arterial provides greater mobility increases than any of the bus-lane alternatives.

D. Rail/Bus Cost Numbers

To get a better idea of the cost-effectiveness of express bus and BRT networks, the Government Accountability Office compiled data from the FTA's New Starts and Small Starts programs on recent BRT, light rail (LRT) and heavy rail (HRT) projects. The average cost per route-mile was $124 million for LRT and $154 million for HRT.[124] If a metro area wanted to build a region-wide LRT or HRT system encompassing 250 route-miles, the cost would be $31 billion for LRT or $38.5 billion for HRT. A comparable virtual exclusive busway (VEB) network would require 500 lane-miles with one lane per direction. If all 500 lane-miles had to be added as new construction (i.e., if there were no HOV lanes to convert, at modest cost), the cost would be $5 billion if the average cost were $10 million per lane-mile, or $10 billion if the average cost were $20 million per lane-mile.

Thus, the capital cost of a VEB network would be between *one-sixth* and *one-fourth* that of a rail system of comparable size (though that comparison does not include the cost of additional buses to make full use of the new network). Furthermore, the LRT or HRT capital costs—$30 B to 40 B—would all have to be raised as federal, state and local tax money. Passenger fares would not cover any of that, and would cover only a portion of the operating and maintenance costs. By contrast, the VEB network's capital costs would be partly covered by motorists paying the variable-priced tolls.

Thus, transit capital funds would likely be needed only for the express bus vehicles and any off-line stations and park-and-ride lots developed to enhance the BRT on priced lanes service. Federal highway funding can be used to help fund priced lanes infrastructure, to the extent that toll revenue financing is not sufficient. And FTA grants are available for express buses, stations and park-and-ride lots.

On managed arterials, BRT-heavy has the same problems as express bus service operating in dedicated lanes: acquiring land for a dedicated lane is expensive and few corridors support more than 10 buses per hour. Instead we recommend a BRT-lite service best exemplified by the Metro Rapid program implemented by the Los Angeles County Metropolitan Transportation Authority starting in 2000.[125] It offers limited-stop express bus service in specially marked buses along major arterials. In addition to making stops about 0.7 miles apart (vs. 0.2 miles between stops on conventional bus routes), the service increasingly operates with traffic signal priority at intersections. The initial Metro Rapid line 720 increased transit ridership in that corridor by 40%. Some of the others have seen even greater increases; line 794 has increased ridership by 65% and line 770 by 70%. That success has led to the rapid expansion of the service to 20 other major arterials in Los Angeles County, as of 2014, encompassing 380 arterial-miles and 500 buses.[126]

E. Current and Future Transit Service Recommendations

The following section discusses current transit service and provides specific operating improvements and service expansion guidelines. The final table in this section provides specific suggestions for new BRT, express bus and regional bus lines in the Southern California region.

Southern California has a robust, varied transit network. The following section discusses existing operations and uses our market-oriented transit principles to recommend cost-effective, high-quality future service for the region. A complete table detailing rail, BRT and express bus service is included in Appendix E.

1. Rail

Current heavy, light and commuter rail is a component of the Los Angeles County transit network. Commuter rail is a component in Orange, Riverside, San Bernardino and Ventura Counties with the Orange County Line stretching to Oceanside in San Diego County.

Current Service

Heavy rail lines in operation include the Red and Purple.[127] The Red Line connects North Hollywood with Union Station. The Purple Line connects Wilshire and Western Streets with Union Station.

Light rail lines in operation include the Blue Line, Green Line, Gold Line and Expo Lines.[128] The Blue Line connects Long Beach and Metro Center, The Green Line connects Redondo Beach and Norwalk. The Gold Line connects Atlantic in East Los Angeles with Sierra Madre Villa in Pasadena. The Expo Line connects Culver City with Metro Center.

Commuter rail service in Southern California is operated by MetroLink.[129] MetroLink provides seven lines: Antelope Valley, Orange County-Inland Empire, Orange County, Riverside, San Bernardino, Ventura and the 91 Lines. The Antelope Valley Line connects Lancaster with Union Station; the Orange County-Inland Empire Line connects Oceanside in San Diego County with San Bernardino; the Orange County Line connects Oceanside in San Diego County with Union Station; the Riverside Line connects Riverside with Union Station; the San Bernardino Line connects San Bernardino with Union Station; the Ventura Line connects East Ventura with Union Station; and the 91 Line connects Riverside with Union Station but at different times and with different stops than the Riverside Line.

Both the Red and Purple Lines operate every 15 minutes early in the morning, 10 minutes during rush hour, 12 minutes during middays and 20 minutes during the evenings. Friday evening service departs every 10 minutes. On weekends, service is every 12-15 minutes except Saturday night when service is every 10 minutes and Sunday when service is every 20 minutes. On sections where the Red and Purple Lines overlap, service operates twice as frequently.

The Blue Line operates every 12 minutes during early mornings, 6 minutes during rush hour, 12 minutes during middays, and 10 minutes in evenings. On weekends, the Blue Line operates every 15 minutes until 10:00, then every 12 minutes until 7:00 PM and then every 10 minutes until 1:00 AM. On Saturday nights, trains operate for an additional 90 minutes at 15-minute intervals while on Sunday service ends at 1:00 AM. The Green Line operates every 12 minutes during early mornings, 6 minutes during rush hour, 15 minutes during middays, and 20 minutes during evenings. On weekends, the Green Line operates every 15 minutes except during evenings, when it operates every 20 minutes.

On weekdays, the Gold Line operates every 15 minutes during early mornings, 6 minutes during rush hour, 12 minutes during midday and 10 minutes in evenings. On weekends, the Gold Line operates every 15 minutes until 10:00 AM, then every 8 minutes until 9:00 PM and then every 10 minutes until 1:00 AM. On Saturday nights trains operate for an additional two hours at 20-minute intervals. Sunday night service ends at 1:00 AM. On weekdays, the Expo Line operates every 12 minutes until 7:00 PM and then every 10 minutes until system closing. On weekends, the Expo Line operates every 15 minutes until 9:00 AM, then every 12 minutes until 7:00 PM and then every 10 minutes until 1:00 AM. On Saturday nights, trains operate for an additional two hours at 20-minute intervals. On Sunday nights service ends at 1:00 AM.

Commuter rail trains operate every 30–60 minutes during rush hour and every 90 minutes three hours before or after rush hours. Most lines operate services in both directions but provide more service inbound in the morning and outbound in the afternoon. For example, on weekday afternoons the Antelope Valley Line offers four inbound trains and eight outbound trains.

Operating Improvements

While most Metro rail lines operate peak service during rush hour, the Expo Line operates its peak service at night. As the number of commuters traveling during rush hour is highest, Metro should increase the frequency of the Expo Line during rush hour.

Service Expansion

Los Angeles County has major rail expansion plans. Due to funding challenges and the effectiveness of BRT and express bus at ¼ the cost of light rail, Southern California should reduce its rail expansion plans. The Exposition Line Phase II is under construction so it should be completed to Santa Monica. The Gold Line extension between Pasadena and Azusa is also under construction and we recommend that it be completed. However, the second phase of the Gold Line extension between Azusa and Montclair lacks funding and should be eliminated. The Crenshaw Line that runs between the Expo Line and the Green Line is also under construction and should be completed. This line has several stations near Los Angeles International Airport but no stops at the airport itself, reducing the line's effectiveness. The Purple Line extension between Vermont and La Cienega is under construction and should be completed. However, the second phase of the line between La Cienega and the V.A. hospital, without funding, should be eliminated. The downtown Regional Connector, which builds a new light rail line in downtown Los Angeles connecting the Little Tokyo/Arts District Station on the Gold Line with the 7th Street Metro Center Station, is under construction and should be completed as cost-effectively as possible.

No other rail lines should be built. Instead we suggest building the Green Line extension to Torrance, the Eastside Phase II lines and the East San Fernando Valley Transit Connector as Bus Rapid Transit lines as discussed below. We suggest replacing future commuter rail extensions with express bus service. Southern California has already built or is building all of the rail transit lines that are feasible; no further expansions are justified.

2. Local Bus/Limited Stop Bus/Shuttles

Local buses that offer service up to 22 hours a day are the foundation of any region's transit network. Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties offer local bus service. Los Angeles offers limited stop service during peak travel periods.

Current Service

Los Angeles Metro operates 119 local bus routes and 12 limited or skip stop bus routes.[130] Los Angeles Metro also offers 11 circulators or shuttles that may operate in one or two directions and connect to line-haul services. The Orange County Transportation Authority operates 41 local bus routes, 13 limited stop or skip stop routes including 12 that serve Metrolink Commuter Rail and 14 circulators or shuttles.[131] Omnitrans services the city of San Bernardino and surrounding areas with 27 local bus routes and three circulators or shuttles.[132] Victor Valley Transit Authority operates 20 local bus routes.[133] Foothill Transit provides 26 local routes.[134] Riverside County Transit provides 36 fixed route lines.[135] In Ventura County, Gold Coast Transit provides 18 local bus routes in Oxnard and Ventura.[136]

Operating Improvements

We recommend using intelligent transportation systems technology where possible to increase the quality of service. Queue jumps with priority signaling, traffic synchronization and electronic fare collection can reduce delays.

Service Expansion

L.A. Metro has $21 billion dedicated to bus expansion but does not provide details on specific routes or frequencies.[137] Other transit agencies have not specified any bus service expansions. Expanding service particularly during shoulder times can be a cost-effective way to improve bus system quality.

3. Bus Rapid Transit/Express Bus

Express bus and bus rapid transit (BRT) are major components of Southern California's transit network. BRT and express bus typically transport commuters longer distances at quicker speeds than local bus service. Express bus and BRT lines often serve as trunk lines, while local bus serves as feeder lines.

Current Service

Los Angeles Metro operates two BRT-heavy lines—the Orange and Silver Lines and 20 BRT-lite lines.[138] Orange County does not have any BRT lines but does have five intra-county express bus routes and five inter-county express bus routes.[139] Omnitrans offers one BRT route and one express route.[140] Victor Valley Transit Authority offers two express routes.[141] Foothill Transit provides eight express routes.[142] Riverside County Transit offers eight express routes that serve transit stations.[143] In Ventura County, VISTA provides six express intra-county bus routes.[144]

Operating Improvements

We recommend all BRT services implement and use the seven premium features detailed earlier in this paper:

- Running ways that give buses priority,
- Unique station design,
- Larger vehicles,
- Electronic smart card/off-board fare collection,
- Intelligent transportation systems including priority signaling and queue jumps,
- More frequent service especially during rush hour, and
- Specific branding

Of these features, intelligent transportation systems are clearly the most important. There is consensus throughout the transportation community that the most important factor in delivering high quality bus service is signal priority.[145] Yet some BRT lines in Los Angeles feature priority signaling only during peak periods. To realize the maximum benefits from BRT, such lines need to use signal priority whenever they operate.

Some express bus lines operate in general purpose expressway lanes or on congested arterials. With the implementation of express lanes on expressways and managed arterials on arterials, these buses should take advantage of the guaranteed reliable travel times free for transit vehicles in these lanes.

4. Vanpools

A vanpool consists of a commercial van and a group of seven to 15 people who ride to and from work together. Most vanpools require a small monthly charge to pay for gasoline and insurance. Since seven to 15 people share the costs, however, commuting by vanpool is substantially less expensive and less time-consuming than commuting alone. Similar to buses, vanpools can use express lanes and managed arterials free of charge, reducing commute times even further. The driver and substitute driver for most vanpools either do not have to pay or receive a significantly discounted price.

While vanpools can receive a small subsidy from the county, the subsidy is typically far less per capita than fixed-route transit. Additionally, private sector companies including Enterprise Rideshare and Veolia's vRide operate many of the vanpools in California.[146]

Computer applications are increasing the popularity of vanpools. Traditionally, vanpools are static arrangements of travelers booked in advance. Smartphones are allowing potential riders to vanpool in as little as 30 minutes in advance.[147] Some of these riders may choose to vanpool several times a week while others may vanpool as little as once a month.

Current Service

All Los Angeles counties offer some type of vanpooling service. Some counties allow potential riders to enter their addresses and be matched into a vanpooling service. Others have vanpool coordinators that arrange riders.

Planned Expansion

Any group of seven to 15 people with similar residential and commercial destinations can vanpool. The county/private sector will supply a vehicle and insurance for the drivers.

5. Casual Carpools

A casual carpool is a less organized form of vanpooling where commuters form carpools to take advantage of HOV or HOT lanes. Casual carpooling has proven successful in Houston, San Francisco and Washington, D.C., but it has not been as popular in Southern California.[148] Forming a casual carpool is a simple, quick process. A car needing additional passengers to meet the required minimum occupancy requirements of an express lane pulls up to one of the casual carpool lines. The driver usually positions the car so that potential passengers can enter on the passenger side. The driver either displays a sign with the vehicle's destination or simply lowers the passenger window to call out the destination. The passengers first in line for that particular destination then get into the vehicle. Metro agencies can encourage such casual carpool lanes by providing dedicated meeting places near highway entrances (including at park-and-ride lots). While new users sometimes have safety concerns, casual carpooling has been in effect for 20 years in Houston without a single reported incident.

6. Demand-Response Transit

With demand-response transit (DRT) service, individual passengers can request a ride from one specific location to another location at a certain time. Unlike local bus service, which offers a fixed-route service, the passenger must notify the transit operator of the need for service and the destination before he or she travels.

There are two types of DRT service. In suburban and rural areas with low populations, DRT service is offered in lieu of fixed-route transit service as a more cost-effective transit option. In denser areas, DRT service is for elderly and disabled residents who cannot use fixed-route transit services. The Americans with Disabilities Act requires that transit providers that offer fixed-route service must offer DRT service as well. Buses, taxis, vans and cars are used as DRT vehicles.[149]

As demand-response service typically has higher per capita costs than fixed-route service, most operators contract with the private sector to provide quality demand-response service at a lower cost. Most L.A. area counties contract out DRT service.

Current Service

All counties in the L.A. region provide demand-response service for the elderly and disabled. Some counties provide demand response service in low-density areas where fixed-route service would be inefficient. Omni Link in San Bernardino County provides demand-response service in low-density areas of the county while VISTA in Ventura County provides demand-response service in low density areas of the county.

Table 28: Demand-Response Transit Service in L.A. Region		
County	Service Provider	Type of Service
Los Angeles	Metro	Elderly/Disabled
Orange	OCTA	Elderly/Disabled
San Bernardino	OmniLink	Low Density
San Bernardino	Access	Elderly/Disabled
Riverside	Dial-A-Ride	Elderly/Disabled
Ventura	Gold Coast Access, VISTA, VCTC Ride Share	Elderly/Disabled
Ventura	VISTA	Low Density

Expansion

Eastern Riverside, eastern San Bernardino and western Ventura Counties are very rural areas where fixed-route transit will remain unfeasible. Demand-response transit would be very effective in these areas. There is also a growing population of elderly and disabled residents who are unable to use fixed-route transit due to special medical conditions. As a result, substantial growth in demand-response transit is expected in both rural and urban areas.

Table 29: Express Bus/BRT/Regional Bus New Lines			
BRT Line	Starting Point	Ending Point	Service Type
Roscoe Blvd	Roscoe Blvd at Woodlake Ave	Tujunga Canyon Blvd at Foothill Blvd	BRT
Las Tunas Dr	6^{th} St at Flower St/Figueroa St	Live Oak Ave at I-605	BRT
Slauson Ave	SR 1 at SR 90	Carbon Canyon Rd at Chino Hills Parkway	BRT
Euclid Rd	Torrance Blvd at Palos Verde Blvd	Cannon St at Santiago Canyon Rd	BRT
Portola Parkway	SR 1 at Warner Ave	Portola Parkway at SR 133	BRT
SR 79	I-5	San Jacinto Rd	Regional
SR 1	SR 107	Chautaqua Blvd	BRT
SR 27	Burbank Blvd	Chatsworth St	BRT
La Cienega Blvd	Florence Ave	Foothill Blvd	Regional
Alameda St	Carson St	First St	BRT
SR 19	SR 1 at SR 19	E. Sierra Madre Blvd at Sierra Madre Villa Ave	BRT
Western Ave	Western Ave at SR 1	Western Ave at Century Blvd	BRT
SR 1	Beach Blvd at SR 1	Azusa Ave at Sierra Madre Ave	Regional
Euclid Ave	Euclid Ave at Eucalyptus Ave	Euclid Ave at 19^{th} St	BRT
Sierra Ave	Van Buren Blvd at Victoria Ave.	Sierra Ave at Sierra Lakes Parkway	BRT
SR 39	SR 1 at SR 39	SR 39 at SR 72	BRT
Van Nuys Blvd	Van Nuys Blvd at Ventura Blvd	Van Nuys Blvd at Glen Oaks Blvd	BRT
Mission Blvd/Van Buren Blvd	March Air Reserve Base	Mission Blvd at Garey St	BRT
I-710/Imperial Highway	Downtown L.A.	Santa Ana Canyon Rd at Imperial Hwy	Express bus/BRT
Jamboree Rd/SR 241/SR 91	Jamboree Rd at SR 1	Main St at 6^{th} St, Corona	Express bus/BRT
Trabuco Rd/Irvine Blvd/4^{th} St	Marguerite Parkway	Main St at 4^{th} St, Santa Ana	BRT
SR 55/Harbor Blvd	SR 1 at SR 55	Harbor Blvd at SR 90	BRT
Victoria Ave, Ventura	Victoria Ave at Channel Islands Blvd	Victoria Ave at Telegraph Rd	BRT
Huntington Dr/SR 66/Foothill Blvd/5^{th} St	Santa Anita Ave, Arcadia	Boulder Ave, Highland	BRT

F. An Express Bus and BRT Transit Network

1. Express Bus Numbers

Express bus and BRT are two different transit services operating in different environments. Southern California has a number of express bus lines operating on different expressways. The following table provides details about many of the lines.

Southern California currently has more than 20 express bus lines with most transit operators in the region operating at least one line. Across the country managed lanes have increased the number of people taking bus transit and decreased the travel times. Table 30 shows the ridership in various express bus lines across the country. Table 31 shows how residents commuted prior to the express buses.

Table 30: Express Bus Ridership Before and After HOT Lanes

Agency	Line	Before Weekday Ridership	After Weekday Ridership	Percent Increase	Operates Outside Peak Hours
Gardena	2	3,672	3,916	9.8%	No
L.A. Metro	Silver	7,201	10,522	46.1%	Yes
Miami-Dade Transit	95X, Pines Express, Dade Broward Express	1,800	4,500	150.0%	No
GA Xpress	410,411,412, 413,416	3,383	3,793	12.1%	No
Minnesota DOT	I-35W	10,600	12,300	16.0%	Yes

Sources: U.S. Department of Transportation, Los Angeles Metro, Center for Urban Transportation Research, Georgia Institute of Technology

Table 31: Express Bus Ridership, Commute Mode Before

Agency	Line	Bus	Carpooled	Drove Alone	Other Transit	Other	Did Not Make Trip
Gardena	2	N/A	N/A	N/A	N/A	N/A	N/A
L.A. Metro I-10	Silver	33%	5%	11%	33%	19%	N/A
Miami-Dade Transit	95X, Pines Express, Dade Broward Express	N/A	N/A	38%	34%	N/A	N/A
GA Xpress	410,411,412, 413, 416	N/A	N/A	N/A	N/A	N/A	N/A
Minnesota DOT	I-35W	28%	4%	28%	N/A	10%	32%

Sources: U.S. Department of Transportation, Los Angeles Metro, Center for Urban Transportation Research, Georgia Institute of Technology

As the two tables show, express bus ridership in electronic toll lanes increased in all five of the above examples between 10% and 150%. The rate of increase varied based on several factors including HOV/HOT lane congestion, bus additions, gas prices, and other lane additions. While several transit agencies purchase additional buses with funds from the Urban Partnership or Congestion Reduction Demonstrations projects, those agencies have continued operating those buses even after federal funding ceased. This indicates that these buses have developed a stable following. The L.A. Metro Silver Line had the second largest increase in ridership (46%) of any of the lines studied, while the Gardena Line 2 had a more modest 10%

increase. This indicates that converting HOV lanes to express lanes and building additional express lanes will increase transit usage throughout Southern California.

Express buses also reduce the share of commuters driving alone. The numbers range from 11% in Los Angeles to 38% in Miami-Dade County. Even a small reduction in the number of vehicles on a stretch of roadway can have a big impact on congestion. Therefore, managed lanes are a true win/win proposition. Not only can they increase transit ridership in the corridor but they can also reduce congestion by decreasing the number of vehicles on the road.

We calculated the number of express bus riders on five potential new routes throughout Southern California.

Table 32: Potential Express Bus Corridors

Roadway	From	To	Primary Direction	Estimated Daily Ridership
US 101	SR 27/Woodland Hills	Downtown L.A.	E/W	10,000
SR 60	Van Buren Blvd/Jurupa Valley	Downtown L.A.	E/W	10,000
I-5	Laguna Niguel	Culver Dr/Irvine	N/S	8,000
I-210	Glendora	Pasadena	E/W	6,000
I-5, I-605	Cypress	Downtown L.A.	N/S	10,000

Daily express bus ridership on each of the corridors is estimated at between 6,000 and 10,000. While these numbers might seem underwhelming, express bus ridership has very low capital costs since buses will travel on the express lanes. Additionally, express buses operate during weekday rush hours only. Given the low costs and limited hours, express bus is a very cost-effective transit option.

2. BRT Numbers

Los Angeles currently has two BRT-heavy lines and 20 BRT-lite lines. Table 33 shows the ridership numbers from selected BRT-heavy lines around the country. BRT-heavy lines have a dedicated right-of-way for at least part of the trip.

Table 33: BRT-Heavy Ridership Across the Country (Average 2013)

Agency	Name of BRT	Transit Area Population	Urbanized Area Density	Length (mi.)	Weekday Ridership	Weekday Riders per Mile
Los Angeles County MTA	Orange Line	8,626,817	6,999	18.7	29,123	1,557
Miami-Dade Transit	South Miami-Dade Busway	5,502,379	4,442	19.9	20,000	1,047
The Greater Cleveland RTA	HealthLine	1,780,673	2,307	7.1	13,248	1,866
Lane (Eugene, OR) Transit District	Emerald Express	245,721	2,582	15.3	9,041	591
RTC of Southern Nevada	MAX	1,886,011	4,525	20.8	12,509	601
Port Authority Transit (Pittsburgh)	Busways	1,733,853	1,916	28.2	9,000	321

Source: National Transit Database, http://www.ntdprogram.gov/ntdprogram/data.htm

Table 34 shows the data from five of the 20 BRT-lite lines operating in Los Angeles.

Table 34: BRT-Lite Ridership in Los Angeles (October 2014)

Line No.	Length (mi.)	Weekday Ridership	Weekday Riders per Mile
Santa Monica	18.7	33,201	1,775
Wilshire	23.0	58,077	2,525
Venice	18.6	25,625	1,378
Vermont	12.3	47,430	3,856
Western	10.3	35,587	3,455

Source: Los Angeles Metro, https://www.metro.net/news/ridership-statistics/ and https://letsgola.wordpress.com/2014/11/16/lacmta-ridership-update-october-2014/

Looking at the first table of BRT-heavy lines across the country, there is wide variation in the ridership numbers. Smaller cities such as Eugene, Oregon tend to have lower ridership numbers per capita while larger cities such as Los Angeles tend to have higher ridership. In addition, longer lines tend to have slightly fewer riders per mile. Looking at the table of BRT-lite lines in Los Angeles, while lines vary in length from between 10 to slightly over 23 miles, each has at least 1,378 riders per mile. Comparing the tables, four of the five BRT-lite lines have more total riders and more riders per capita than the Orange Line BRT-heavy line. Since the Orange Line is considered the gold standard for U.S. BRT lines, this shows the success of the BRT-lite ridership (also called Metro Rapid) in the L.A. region.

Further, BRT operating on arterials is likely to have higher ridership estimates. First, none of the current BRT-lite lines have grade separations that buses can use to bypass congested intersections. Such intersections will likely reduce travel times up to 50% during peak hours. We estimate that this would reduce the scheduled travel time on the Wilshire BRT from 90 minutes to 40-55 minutes. Second, the current priority traffic signaling only operates during rush hours. This priority signaling could substantially reduce travel times during peak hours. Clearly, congestion is not as severe middays, evenings and weekends, but turning on signal priority 18 hours a day, seven days a week would reduce transit travel times and not adversely affect vehicle travel times. Finally, Southern California's urban areas could easily implement off-board payment for Metro Rapid, the one of the seven key features of BRT not featured.

We calculated potential ridership for eight BRT lines operating on managed arterials. Note that one of the lines mirrors an existing BRT corridor and a second line extends an existing BRT corridor. Our calculations assume that Metro uses optional priced underpasses, uses priority traffic signals 18 hours a day, and implements off-board payment. Those details are in Table 35 below.

Table 35: 2020 Estimated BRT Ridership on Selected Corridors

Managed Arterial	From	To	Primary Direction	Estimated Ridership	Miles	Ridership/ Mile
Roscoe Blvd	SR 27	SR 170	E/W	25,000	11.5	2,174
Santa Monica Blvd (Current Santa Monica Line)	Ocean Ave	Union Station	E/W	52,000	18.7	2,781
Carson St/Lincoln Ave/Taft Ave	Palos Verdes Blvd	Cannon St	E/W	39,000	35.0	1,114
Slauson Rd/ Telegraph Rd/ Imperial Hwy	SR 1	Valencia Ave	E/W	48,000	38.1	1,260
Western Ave (Current Western Line and Extension)	SR 1	Franklin Ave	N/S	72,000	22.7	3,179
Laurel Canyon Blvd	Ventura Blvd	Webb Ave	N/S	32,000	13.7	2,336
Lakewood Blvd	SR 1	Foothill Blvd	N/S	58,000	26.2	2,214
Beach Blvd, Azusa Ave	SR 1	SR 72	N/S	46,000	20.8	2,212

The table shows that managed arterials have a significant positive effect on BRT ridership. Managed arterials are forecast to increase current Santa Monica line ridership by 60%. Note that each of the lines operates with at least 1,100 riders per mile and some exceed 3,000 riders per mile. These ridership numbers would make Los Angeles BRT lines some of the most heavily used per mile in the country and set a new gold standard for bus service.

BRT-lite has significant cost advantages compared to BRT-heavy. A recent Transportation Research Board paper compared Metro Rapid service on Ventura Blvd. in L.A.'s San Fernando Valley with parallel BRT-heavy service on the area's then-new Orange Line exclusive busway. The travel times were about the same for both, but the capital cost per boarding was only $1,300 for the BRT-lite versus $16,800 per boarding for the BRT-heavy service, primarily because of the exclusive-guideway cost for the latter.[150]

BRT-lite appears to be a highly cost-effective way to expand transit service on arterials. And just as express bus is well-suited to operate on express toll lanes on expressways, BRT-lite could take advantage of managed arterials to operate faster than what is possible on ordinary arterials. This would expand the network of region-wide BRT to the corridors with managed arterials, in addition to the express lane network. BRT-lite service can be added on traditional arterial roads. Services on traditional arterial roads will not offer the same speeds as those operating on managed arterials, but will still be considerably faster than local bus.

3. Express Bus and BRT Costs

Since express buses and BRT are premium transit services that operate more quickly than typical buses, most transit agencies charge a higher fare. Metro charges $2.50 for the Silver Line express bus and between $2.50 and $3.25 or more for express buses depending on length and whether or not the bus travels on the expressway. Xpress in Georgia charges between $3.50 and $5.00 depending on length and operating agency. Fares for BRT lines are the same as those for regular bus service. While most transit agencies have tiered pricing for express buses, all transit agencies except RTP of Southern Nevada charge the same price for BRT as local bus. Charging the same price for a traditional local bus that stops every few blocks as for a bus that operates in a semi-dedicated right of way with priority traffic signaling and service improvements that stops every ¾-1 mile is the wrong approach. We recommend Southern California transit agencies charge a higher price for both express bus and BRT. We have calculated the numbers using higher fares adjusted for inflation. The following table estimates revenue per BRT line and express bus line.

Table 36: Estimated Express Bus and BRT Revenue 2020

	Express Lane	Managed Arterial
Projected Daily Riders	8,000	40,000
Annual Weekday Ratio	250	365
Average Fare	$4.00	$2.50
Average Gross Fare Revenue	$11,680,000	$25,000,000
Farebox Coverage	90%	30%
Revenue	$10,512,000	$7,500,000

For each type of premium bus service we projected average revenue from new riders only. We first calculated average ridership per line based on current ridership in Southern California. While express bus ridership may seem a little low, each expressway could have multiple express bus lines. For example, I-5 between I-605 and downtown Los Angeles could have three lines operating, so the number of express bus riders would be 24,000. We assumed express bus would operate five days a week, not major holidays, and that bus rapid transit would operate seven days a week. We raised the average express bus fare to $4.00, comparable today to fares in Atlanta and other major cities. We raised BRT fares to $2.50 higher than current fares in Los Angeles but lower than those in Las Vegas and other large cities. We assumed that almost all new express bus riders would be new riders but that only 30% of BRT riders would be new. Due to Southern California's extensive local bus service, we expect 70% of BRT riders to switch from local service. These factors help determine the amount of new revenue per line.

Since significant numbers of BRT riders are expected to shift from local bus to BRT, some local bus funding could shift to support BRT service. We don't expect farebox revenue to cover the complete cost of providing BRT service. Value capture and transit advertising can help fund the remainder of BRT costs, although a limited amount of general fund revenue may be necessary.

While exact ridership will vary by line, the above table indicates many BRT and express lines should come close to covering their operating and potentially maintenance expenses through farebox revenue and some use of value capture. This funded ratio is two to three times traditional local bus service. Since the running way (paved lanes) are paid for by automobile users, the only remaining cost is the capital costs of the buses themselves. While it is beyond this study's reach to determine the exact financial details of a comprehensive express bus and BRT network, calculations indicate express bus and BRT should be among the most cost-effective forms of fixed-route transit service that Southern California transit agencies offer.

4. Current Conditions and Planned Expansions

Complete details on Southern California's current transit service are available in Appendix D. We also recommend several new express bus, regional bus and BRT lines and extensions. In addition to the corridors highlighted above, we have recommended 25 other leading corridors for bus service. Line details are available in Appendix D. However, transit planners should not stop with these lines. There are probably an additional 100 lines, half of them local or limited-stop, that Southern California should add. Determining the location and headways of future lines will require a detailed travel demand survey, which we encourage local travel agencies and SCAG to pursue.

We recommend all services operate on headways of no more than 10 minutes during peak periods, 15 minutes during middays and evening, and 20 minutes during weekends. All services should operate between 5 AM and midnight on weekdays and 7 AM and midnight on weekends. Lines serving popular nightspots should operate until 2 AM Friday and Saturday nights.

G. Conclusion: Next Steps for Southern California Transit

Southern California has good transit service, but the region should consider additional expansions. Due to the region's spread-out nature and its dispersed employment locations, adding bus service will be more effective and efficient than adding rail service. We recommended additional BRT, express bus and regional bus additions earlier in this section. Local bus additions are also needed but beyond the scope of this report.

Part 10

The Smart City: Operational Strategies for Reducing Congestion

"Operations management" is the set of strategies used to maximize existing infrastructure and reduce non-recurrent congestion. Operations management alone cannot make up for needed capacity or reduce recurrent congestion. But operations management can significantly improve mobility, typically at a very low cost. For example, the California DOT (Caltrans) estimated a package of system operations measures to have a cost-benefit ratio of 8.9 to 1.[151] By contrast, the addition of conventional highway capacity had a benefit-cost ratio of 2.7 to 1. While both need to be completed, the low-hanging fruit is the system operations measures, which have the advantages of being (1) relatively inexpensive, and (2) implementable within a matter of years, rather than decades.

In many areas, operations management can substitute for some needed capacity. Using dynamic traffic management system data, ramp metering, variable speed limits, signal optimization, queue jumps and other "intelligent transportation systems (ITS)" can help increase mobility by increasing the number of cars a given stretch of pavement can accommodate.

The following section discusses the role of dynamic traffic management systems in operations management. It then details how the components of freeway operations and arterial operations reduce congestion.

A. Dynamic Traffic Management Systems and Intelligent Transportation Systems

Dynamic traffic management systems are cost-effective systems that improve traffic flow on expressways and arterials. Dynamic traffic management systems use simulation models combined with real-time traffic information to predict the effects of various management strategies.[152] Route time, travel time and departure time are collected from sources of real-time information such as loop detectors, roadside sensors and GPS devices. This travel information is used with simulation models to predict network flow patterns and travel times on routes, given the combination of management strategies used on those routes, including incident management, ramp metering, signal control and traveler information. Based on these predictions, the system selects optimal strategies and suggests travel time predictions and route recommendations to travelers. These programs have been successfully deployed in Europe and Japan resulting in capacity improvements on major expressway corridors of up to 30% as well as significant increases in trip predictability and safety.[153]

Intelligent transportation systems (ITS) are the most popular subset of dynamic traffic management systems. U.S. engineers have been implementing ITS for over two decades and have installed vehicle sensors and message signs, as well as backbone communications systems, on many major urban expressway corridors and selected arterial highways.[154] These sensors gather data about traffic conditions on a 24/7 basis, and this information is collected, compiled and distributed to the motoring public in near real-time through a variety of public and private information channels.

Many metro areas use several ITS systems that operate in *static* mode. However, ITS systems would be even more effective if they operated in a *dynamic* mode. In "static mode" expressway incident management and service patrols quickly *observe, respond to* and *clear* accidents from travel lanes. But in "dynamic mode" ITS systems seek to *prevent* accidents by reducing speed limits and warning of congestion. Traffic signs that report congestion ahead provide valuable information to motorists. However traffic signs that detail congestion and suggest alternate routes and where to exit the highway to avoid congestion, a.k.a. "dynamic mode," are even more useful.

The California Department of Transportation (Caltrans) operates a partially dynamic traffic monitoring system called "Quickmap" that provides updated information on changeable travel signs.[155] The website provides traffic cameras and information on travel alerts, weather, road conditions, speeds, roadwork, detours and information to truckers. Caltrans also has a mobile application for smart phones, but the agency could improve its service by providing real time updates of incidents and severe congestion events. The state also uses other dynamic systems, such as converting a shoulder to a direct exit lane. However, the state needs to complete its transition from a static plan to a dynamic operations plan. The following paragraphs detail several leading dynamic ITS technologies.[156]

Ramp metering uses a traffic control device, typically a red and green traffic light, and a signal controller that regulates the flow of traffic entering expressways at current traffic conditions.[157] Ramp metering restricts the total flow of vehicles entering roadways by temporarily storing it on an on-ramp. Ramp metering decreases congestion by reducing demand and eliminating platoons of cars jamming up the right-most expressway lane. Most major metro areas use static ramp metering. Metro areas need to adopt active ramp metering systems calibrated to adjust to traffic in a demand-responsive mode. Imagine a two-lane highway on-ramp that at 7:00 AM has 20 cars in the left lane and five in the right and at 8:00 AM has seven cars in the left lane and zero cars in the right. With a static ramp meter one car from each lane of an on-ramp would enter a highway per green signal for the entire morning rush hour. With an active ramp meter, at 7:00 AM four cars would enter from the left lane per green signal for every car that entered from the right lane per green signal. At 8:00, with a different traffic pattern, the ramp meter would turn green for the left lane but stay red for the right lane since there is no traffic in the lane. Active ramp metering does much more to reduce congestion.

Static **queue warnings** are electronic signs that detail travel speeds and travel times that may change due to congestion, traffic construction or an accident. They can be used for traffic control on congested facilities or to enhance safety during major incidents. Dynamic queue warnings offer the same features, but they also suggest alternate routes and provide detailed guidance on when the congestion starts. Dynamic signs are often placed at expressway entrances so drivers can choose an alternate route before they enter the highway.

Speed harmonization uses variable speed limits to smooth traffic flow and improve safety.[158]

Hard shoulder running involves upgrading shoulder pavement quality and opening shoulders to traffic during peak periods.[159] Some states have converted shoulders to general purpose lanes and allow traffic to use them 24 hours a day, seven days a week. Shoulder lanes are used to increase capacity on constrained highways.

Junction control uses signs, typically red and green electronic signs, to open and close lanes based on conditions.[160] For example, if there is an accident in the middle lane of three lanes, road operators may place a red X in the box over the middle lane to indicate that it is closed and drivers should move to the right or left.

The most effective active transportation systems use multiple technologies together. For example, queue warnings are used in conjunction with speed harmonization to slow speeds and warn drivers of congestion ahead.

Enforcement of these dynamic roadway systems is important. While traditional enforcement—a police officer sitting in a patrol car—is still used, automated enforcement is much cheaper and safer. Many states use automated traffic cameras to ensure drivers obey dynamically imposed operating signs. If drivers do not obey the signs, the enforcement system mails a ticket to a violator's home address.

Since comparative dynamic ITS traffic system data are limited, we have assessed Southern California's systems based on the data available. But the urban area is encouraged to upgrade to more dynamic ITS systems wherever possible.

B. Expressway Operations

The Texas Transportation Institute's annual *Urban Mobility Report* provides summary data for each urban area on operations strategy measures, estimating each one's contribution toward reducing the travel time index.[161] Four basic measures are reported, two for expressways and two for arterials. The expressway measures quantify the extent of ramp metering and the percentage of the system under active incident management efforts. The most recent expressway data for the Los Angeles region is shown in Table 37.

Table 37: Expressway Operations Management for the Los Angeles Urbanized Area

Operations Strategy	2011	2010	2009	2008
Ramp Metering				
Percent miles of roadway	100%	99%	99%	100%
Annual delay reduction, (thousands of hours)	20,316	20,155	19,904	17,944
Freeway Incident Management				
a) Cameras				
Percent miles of roadway	71%	71%	70%	71%
b) Service patrols				
Percent miles of roadway	95%	94%	94%	95%
Annual delay reduction, (thousands of hours)	18,285	18,139	17,913	16,149

Source: *2012 Urban Mobility Report*, Texas A&M Transportation Institute, Texas A&M University. The Los Angeles Urbanized Area covers portions of Los Angeles and Orange Counties.

At 100% of miles covered, virtually every on-ramp in the Los Angeles – Long Beach – Santa Ana area uses expressway metering, resulting in estimated annual delay reductions of over 18 million hours.[162] However, in other portions of Southern California, the percent of miles covered is lower (59% in Riverside-San Bernardino, and virtually no application in Oxnard-Ventura). Additional investments could reduce delay further and build on the region's current successes in this area. If Riverside/San Bernardino and Lancaster/Palmdale implement comprehensive expressway ramp metering where needed, the region might save an additional 1.1 million hours of delay. Since ramp metering costs much less than significant lane additions, this under-used tool clearly represents "low-hanging fruit" in reducing Southern California's congestion. While ramp space can be an issue in some places, most of Riverside/San Bernardino's and Lancaster/Palmdale's expressways have enough "storage" space for vehicles in on-ramp queues.

Incident management has become a popular tool used to combat non-recurrent congestion in large metropolitan areas. Typical incidents include disabled vehicles, traffic crashes, spilled cargo or other debris in the road, road construction and non-emergency special events. Pro-active incident management in Southern California is intended to cover incident detection and verification, incident response and clearance, and site and area traffic management. One of the more obvious examples of the deployment of this strategy is the variable message signs over expressways throughout the region alerting travelers to delays and traffic accidents.

Two key elements include equipping the expressways with cameras so that incidents can be identified quickly and appropriate units dispatched, and creating and operating expressway service patrols that can respond rapidly to minor incidents (breakdowns and fender-benders). On the former, Los Angeles is ahead of the pack, with 71% of expressway-miles equipped with traffic surveillance cameras as of 2011, compared to an average of 52% for other large metropolitan areas.[163] Riverside-San Bernardino does even better at 77% and Oxnard-Ventura at 24%. However, those percentages have held steady for the past four years. Each region should try to cover the remaining expressways within the next five years.

Los Angeles also has expressway service patrols in place, covering 95% of expressway-miles. Riverside-San Bernardino covers 78%. The patrols' duties include detecting expressway incidents by patrolling metro expressways and quickly responding to and removing incidents (pushing disabled vehicles using push bumpers and removing debris) from the traffic lanes. They are also responsible for providing traffic control and scene security at crashes, assisting first responders with first aid at crash scenes and assisting motorists with emergency vehicle repairs. Service patrols also clear stalled vehicles and debris in the roadway. The congestion from these incidents is responsible for causing about 15% of all expressway crashes, known as "secondary crashes."[164] Every minute a highway lane is blocked can cause four to five minutes of additional delay, so it is critical to clear the roads as quickly as possible.[165]

Several states have analyzed the congestion created by incidents and the advantages of better incident management systems. The Washington State DOT estimates that the throughput on a six-lane expressway (three per direction) can be cut 20% by a car out of gas on the shoulder, 50% by a disabled car blocking one lane, and 85% by an accident blocking two lanes.[166] Rapid response and rapid clearance of such incidents can significantly reduce the duration of such congestion, allowing the expressway's capacity to be reclaimed. The Bay Area Toll Authority estimates a benefit/cost ratio for such projects as 8:1.[167] Such projects typically involve advanced video systems to quickly spot incidents, dispatch centers to send appropriate response crews and expressway service patrols to quickly deal with minor incidents.

Table 38 below illustrates the cost-effectiveness of the Los Angeles region's Safety Patrol program.

Table 38: Expressway Service Patrol Data

Urbanized Area	Annual Cost ($ million)	Miles Covered	# Vehicles	Benefit/Cost*
Los Angeles, CA	$23.1	411	146 tow trucks	15:1
San Francisco Bay Area, CA	$6.0	362	60 tow trucks	11:1
Chicago, IL	$5.5	80	35 tow trucks	17:1
San Diego, CA	$2.4	203	26 tow trucks	7:1
Houston, TX	$1.4	190	18 vans	6.6:1 to 23:1
Denver, CO	$1.3	60	12 tow trucks	20:1 to 23:1
Minneapolis/St.Paul, MN	$1.0	220	10 pickup trucks	15.8:1

Source: Regional Transportation Management Center

*The benefit/cost calculations are not directly comparable due to the differing assumptions and methods used between agencies. MnDOT's benefit/cost ratio was calculated more conservatively than other metro areas.

C. Institutional Conflict

One challenge with incident management is institutional conflict. Public safety agencies tend to have one set of priorities while transportation agencies have a different one. Besides tending to the injured and dealing with fuel spills, public safety agencies are concerned about thoroughly investigating and documenting major accidents, which can take considerable time.

Transportation agencies are concerned with the huge delay costs imposed on cars, buses and delivery trucks that use the highways. In most states, including California, public safety agencies are either legally or de-facto in charge at incidents, which means that minimizing delay to the traveling public does not receive priority. This is less the case on certain toll roads such as California's 91 Express Lanes, with a different approach to clearing incidents. The National Cooperative Highway Research Program published a synthesis report on safe, quick clearance of traffic incidents that detailed four steps municipalities can take to minimize the accident delays.[168]

- Quick clearance legislation;
- Hold harmless law for incident responders;
- Fatality certification law;
- Interagency agreements (open roads policy).

Quick clearance is the process of rapidly and safely removing temporary obstructions including wrecked vehicles, debris and spilled cargo. All states have some type of quick clearance legislation.

A hold harmless law is formal legislation that protects the public, emergency responders, and in many cases all on-scene responders from liability "in the absence of gross negligence" as a result of their actions. California has one of the most comprehensive hold harmless laws in the country that protects all on-scene responders from liability. California's law in this area serves as a national model.

On the other hand, California does not permit the certification of a fatality and removal of the body by anyone other than a medical examiner—yet such policies can make a major difference in accident clearance times. A growing number of jurisdictions have such policies, including the city of Chicago and the states of Maryland, Tennessee and Texas.

Likewise, only a few states have developed enhanced interagency agreements that make quick clearance the overarching priority, commonly termed an "open roads policy." Some states including Connecticut, Florida, Georgia, Maryland, Tennessee, Washington and Wisconsin have formal open roads policies—but California does not.

California policymakers should pursue the enactment of a fatality certification law and development of an open roads policy among Caltrans, county and local DOTs and public safety agencies.

D. Operations Management and ITS in Critical Expressway Situations

ITS can help reduce congestion and increase safety on most every road in most any situation. However, there are two situations—highway construction zones and winter weather—where they are especially useful.

Highway construction zones are another key source of delay, as well as a safety concern.[169] There are two different types of highway construction: routine resurfacing and major reconstruction projects. Both can be managed in ways that minimize the delay caused to motorists. For example, Caltrans schedules and performs work during off-peak periods and at night, where possible.

Routine resurfacing must be completed periodically to maintain the life of the pavement, thereby preventing major reconstruction before it is really necessary. On highly congested expressways, such resurfacing operations should not be completed during peak traffic periods, because the loss of lane capacity imposes too great a cost on users. But since "peak" periods in California can last 12 hours or more and occur on weekends as well, this means such resurfacing must be completed at night and during the early mornings and late afternoons on weekends. The additional cost of night and weekend operations is far less than the delay costs that would otherwise be imposed on highway users.

Major reconstruction projects impact roadways for a substantial period of time—typically several months to many years. When possible, all lanes on major expressways should be kept open. This might entail building temporary lanes, narrowing lanes and/or restricting certain vehicles. If lanes must be closed, the construction work should be carried out on a round-the-clock basis (24/7), with the idea of limiting the duration of construction to as short a time as possible. When such projects are constructed under design-build contracts, it is common to include significant financial incentives to complete the work on or before a target date, and such projects are often completed significantly ahead of the targeted completion date.

ITS systems in the vicinity of construction work zones can reduce delay and improve safety by reducing accidents and the delays associated with clearing them. Using design-build contracts to build these projects can limit delays because such contracts contain financial incentives to complete the work on or before a target date.

Winter weather is another substantial concern in the mountains north and east of Los Angeles. Caltrans posts traffic congestion and weather advisories. It could augment the program by suggesting alternate routes and quickly closing local roads that cannot be speedily treated.

E. Arterial ITS Assessment

Two principal operations strategies for arterials are traffic signal coordination and arterial access management. The Texas Transportation Institute data for the Los Angeles region's use of these strategies is presented in Table 39.

Table 39: Arterial Operations Management for Los Angeles Urbanized Area

Operations Strategy	2011	2010	2009	2008
Signal Coordination				
Percent miles of roadway	91%	90%	90%	91%
Annual delay reduction, (thousands of hours)	3,223	3,197	3,158	3,059
Arterial Access Management				
Percent miles of roadway	48%	48%	47%	48%
Annual delay reduction, (thousands of hours)	4,711	4,673	4,615	4,471
Annual delay saved per Peak Auto Commuters (hours)	9	9	9	9
Annual Congestion Cost Savings (millions)	1,316	1,306	1,425	1,676

Source: Texas A&M Transportation Institute

*As the Texas A&M Transportation Institute only measures Raised Medians, this understates the amount that access management reduces congestion.

1. Arterial Signal Coordination

The factor limiting arterial capacity (and hence increasing congestion) is intersection capacity, which defines arterial capacity.[170] Traffic signals that are used to control vehicular movements at the intersection of two roadways must, by design, reduce the capacity of both roadways by reducing the number of vehicles that can travel through an intersection during a particular time period. "Green time" is the time allotted to movements through the intersection and is usually expressed as a percentage. For example, if an arterial road has a capacity of 1,800 vehicles per hour per lane with no traffic signals, that same arterial would have a capacity of 1,080 vehicles per hour per lane, with that movement receiving green time for only 60% of the hour (0.60 X 1,800). Sixty percent is a relatively large amount of green time for any one movement to have. Taking into account the cross-street through movements, protected-turning movements, and lost time for clearance intervals, the amount of green time for major movements can easily fall below 50%. It is common for an arterial lane to have less than 50% of the capacity of its uninterrupted flow counterpart.

To reduce congestion, the base traffic light cycle must offer as much green time to the peak direction as possible. Traditionally, traffic engineers have used long traffic signals to extend green time on major arterial highways. As signal timing has become more precise, some engineers have shortened cycles to reduce delays on side streets while still maintaining a higher percentage of green time on arterial highways. This has the advantage of reducing wait times on side streets. But regardless of the approach chosen, it is imperative that traffic light cycles offer a high percentage of green time to traffic on arterial highways—especially the major arterial highways suggested in this report.

One way to give the peak direction as much green time as possible is to "educate" the signal on traffic configuration at any given time, so that it can customize signal timing to serve that traffic at that time most efficiently. Effective traffic signal optimization changes traffic-light signals based on traffic conditions. Highways are fitted with traffic cameras and in-road loop detectors that monitor traffic speeds and congestion. And the pavement near most traffic lights is fitted with loop detectors to notify the traffic light when a car is on a side street. The light will then not turn green for the side street unless the loop detects a car on the side street. Engineers in traffic control centers use the data from these devices to dynamically adjust traffic signals and other traffic control devices, such as reversible-traffic lanes. The sophistication of these systems continues to increase while the cost continues to decrease.

Traffic Signal Priority: ITS systems also enable transit (or traffic) signal priority (TSP), an operational strategy that reduces the delay transit vehicles experience at traffic signals.[171] TSP enables communication between buses and traffic signals, allowing a priority green light as they approach. There are many different types of TSP. These include extending greens on the existing phase, altering phase sequences, and adding new phases that do not interrupt the overall traffic-signal synchronization loop. TSP has a limited effect on signal timing because it adjusts to normal timing and logic to serve a specific vehicle type. TSP can improve transit reliability, efficiency and mobility. It is important to remember that with TSP, a signal change is always optional; the computer or a traffic engineer in a control center can override the request. Moreover, the light cycle will include all phases for all movements—some of these phases may be shortened, but none will be eliminated.

Queue Jumps: Most TSP systems also use queue jumps. A queue jump is a roadway feature that provides a preference to certain vehicles—often transit vehicles—enabling them to bypass long queues (lines) at signalized intersections. Queue jumps are typically paired with signal-priority treatments, which give buses an early green light or extend a green light. An intersection with a queue jump provides an additional travel lane, which can be dedicated to transit vehicles or shared with right-turning vehicles on the approach to a signal. Specifically, queue jumps:

- Help buses to re-enter the traffic stream when a bus lane is ending;
- Allow buses to jump to the front of a queue at a traffic signal after they have picked up passengers at a bus stop; and
- Assist buses in crossing lanes ahead of other traffic to reach a left-turn lane without obstructions.

How does a queue jump work? When a bus reaches a red light in the right-turn lane with a queue jump and decides to use it, the bus receives a special signal to continue through the intersection. Sometimes the signal is instantaneous; other times the bus may have to stop completely and wait for a short period of time. The signal typically precedes the signal for other traffic in the same direction. Sometimes it will interrupt a signal for cross-traffic or for traffic turning left. Optimizing traffic signal timing and installing queue jumps are particularly helpful for BRT and other bus services operating on managed arterials.

The parts of Southern California that have used traffic-signal timing optimization have seen travel times decrease by 13%, delay decline by 21%, and traffic stops decrease by 30%.[172] However, other countries have much more advanced traffic signalization methods. London, England coordinates 3,000 traffic lights using computers to change signal times by just a few seconds to keep traffic moving in the case of accidents.[173] Beijing, China monitors its traffic and posts alternate routes for drivers based on real-time tracking of travel speeds using more than 10,000 taxis.[174]

The share of arterial-miles with signal coordination in the Los Angeles – Long Beach – Santa Ana urbanized area is estimated at 91% in the year 2011, resulting in annual delay reduction benefits of about three million hours.[175] Similar to expressway ramp metering, the Los Angeles region has been highly successful in this area. However, in other portions of the region, the percentage is lower (78% in Riverside–San Bernardino, 70% in Lancaster—Palmdale and Oxnard-Ventura). There is potential to expand the use of signal coordination in these areas. While the average score nationwide was in the low 60s, there is still room to improve in Southern California.[176]

Increasing traffic signal coordination on arterials with a large percentage of vehicles moving in the peak direction is relatively simple if authorities use progression band signal coordination. In a recent signal timing study, the Bay Area Toll Authority in Northern California found that a progression band ("rolling green") of signals in the peak direction, can significantly reduce travel times. Signal timing is less effective on highly congested arterials where traffic is heavy in both directions, but for those arterials where flow is very directional, the benefit-cost ratio can be as high as 35 to 1, according to the Bay Area Toll Authority.[177] Reducing congestion by fixing this simple problem is a very cost-effective solution.

2. Arterial Access Management

Several access management strategies reduce congestion and increase safety.

Access management consists of a set of techniques that increase safety and improve traffic flow on major arterials. It typically includes strategies such as consolidating driveways to minimize disruptions to traffic flow, adding median turn lanes or turn restrictions, adding raised medians and adding acceleration and deceleration lanes.[178]

Because of limitations in readily available highway data, the Texas A&M Transportation Institute uses only the extent of raised medians as its measure of access management. This may understate the extent of congestion reduction since actual programs in urban areas may include other features (e.g, consolidating driveways or adding turn lanes). Nevertheless, data consistency allows for comparable measures across urbanized areas for raised medians. The Los Angeles urbanized area has a fairly significant percentage of principal arterial roadways with raised medians (48%) resulting in annual delay reduction benefits of about six million hours.[179] Nevertheless, there is still ample room to expand the use of this further. Riverside-San Bernardino has raised medians in 35% of its arterials, Lancaster-Palmdale has 13% and Oxnard-Ventura has 46%.

Raised medians are often controversial. Raised medians can make it more challenging to access businesses. They prevent left-turns at certain intersections, usually those without traffic signals. From a traffic management standpoint, during heavy traffic conditions such medians can increase recurrent congestion, due to the limits on storage capacity of left-turn bays. Once they become full, additional left-turning traffic spills into the through lanes, adding to delays. But because raised medians also increase safety by reducing the number of conflict points (thereby reducing accidents), they reduce incident-related congestion. When analysts crunch the numbers, they find a net decrease in congestion from the addition of raised medians, and the safety benefits outweigh the left-bay storage capacity and business accessibility concerns.

Another access management strategy is *consolidating driveways* to minimize disruptions to traffic flow. An Iowa State survey recommends only two to three driveways for a 500-foot city block for roads with a 35 mile-per hour speed limit.[180] Roads with higher posted speed limits should have even fewer driveways.

Adding *median turn lanes* can also improve traffic flow and safety. The Federal Highway Administration found that left-turn lanes increase roadway capacity. A shared left-turn and through lane has about 40-60% of the capacity as a standard through lane.[181] Roadways that add a left-turn lane increase capacity by 25%. The same study also reported that left-turn lanes at intersections substantially reduce rear-end crashes. The research synthesis found that exclusive left-turn lanes reduced crashes by 50% while reducing rear end collisions 60-88%.

Overall, to reduce congestion this report recommends that major primary arterial highways should feature fewer access points through *restriction of left-turning motions*. Left-turning motions should be limited to grade-separated ramps and traffic signals. Side streets should either feature a traffic signal or allow only right-turn access to the primary regional arterial highway. A median or other barrier should separate traffic traveling in different directions. To compensate for fewer turning locations, turn lanes should be lengthened and all traffic signals should allow U-turn motions. Left-turn cycles should be lengthened to reduce queue time.

Where possible, major primary arterial highways should also feature *grade separations* at major side streets. For the purpose of this study, major side streets will typically have at least four through-lanes and average annual daily traffic volumes above 30,000 vehicles. There are several potential grade separations. The first is a full interchange with direct ramps for all turning motions. While this is the best option for two extremely busy roads, costs, aesthetics and neighborhood sentiments may make building full interchanges less than desirable in most situations. Another option is to build a grade separation where the main lanes of the major primary arterial highways travel over or under the side street. Side-street movements and vehicles turning left or right from the major primary arterial highway onto the side street will use a traffic light. Since through-traffic on the major primary arterial highway will use the grade separation, the traffic light will feature longer traffic signals for all other traffic movements.

Many of the techniques discussed in this chapter have been quantified in the NHCRP report referred to in Table 40.

Table 40: Leverage of Systems Operations and Management on Congestion

Problem	Percent of Total Delay	Strategy/Tools	Potential Effect (Percent of Total Delay Relieved)
Crashes & breakdowns	20-42%	Integrated freeway service patrol, incident management program	10-20%
Work zones	8-27%	Advanced work-zone traffic control; automated speed control	4-13%
Weather impacts	5-10%	Prediction/advisory, pre-treatment	2-5%
Uncoordinated Signals	4-13%	Regionwide re-timing	2-5%

Source: Steve Lockwood, "The 21st Century Operations-Oriented State DOT."

It is clear that various operations measures and ITS systems can address incident-related congestion, which is an important element of the region's overall congestion problem. Nevertheless, they can do little to resolve the large and growing mismatch between roadway capacity and travel demand that manifests itself as recurrent congestion.

Part 11

Funding and Financing

We have presented a comprehensive plan to reduce congestion and improve mobility. We have provided approximate costs of the plan and available funding sources. This part of the study summarizes and analyzes the total costs. The first section explains the current revenues available for construction of the highway and transit network. The second section details the total costs of each of our Southern California mobility plan elements.

A. Current Revenues

For the 2015 fiscal year Southern California will spend $9.1 billion on surface transportation.[182] While SCAG is not able to build all of the necessary projects, we believe the answer is not more taxpayer funding but rather greater use of tolling, greater use of P3s and separating the needs from the wants. Our plan is able to fund all of the region's needs without raising taxes.

B. Converting Today's Revenues to Nominal Revenues

For planning long-range expenditures, most transportation agencies convert present dollars to nominal (or year of expenditure) dollars. Table 41 shows the Reason plan's expenditures for capital and operational components in current dollars and inflation-adjusted nominal dollars.

Table 41: Reason Plan's Capital and Operation Components Expenditures

Component	Total Cost (2015 dollars)	Total Cost* Over 25 Years (nominal)
New surface expressways/tunnels	$67.5B	$97.2B
Interchange reconstruction—Expressway	$2.9B	$4.1B
Interchange reconstruction—Arterial	$10.8B	$15.6B
Express toll lanes	$72.9B	$105.0B
Express toll lane interchanges	$16.7B	$24.0B
Managed arterials widening(s)	$11.5B	$16.5B
Managed arterials optional tolled grade separations	$23.4B	$33.7B
Managed arterials new alignments	$2.0B	$2.9B
Transit capital	$29.7B	$42.7B
Intelligent transportation systems	$6.9B	$10.0B
Total	$244.3B	$351.7B

C. Future Projections

Over the next 25 years, SCAG projects transportation spending will total approximately $21 billion (in nominal dollars) per year. Of the total, approximately $12 billion of the annual spending is based on revenue collected and indexed for inflation today with the remaining $9 billion per year based on assumed new revenue.[183]

Of the SCAG region's constrained spending (spending supported by current taxes and tolls), approximately 53% of the total comes from local sources, 25% comes from state sources and 22% comes from federal sources.[184]

Tables 42, 43 and 44 break down the core revenue from existing sources by level of government. Totals have then been converted to reflect a nominal dollars range for 2015-2040.

Table 42: Core Local Revenue Over 25 Years (in Nominal Dollars) in Billions

Local Programs	Funding	Percent
Local Sales Tax	$119.4	53%
Transportation Development Act	$28.7	13%
Farebox Revenue	$26.7	12%
Highway Tolls	$11.2	5%
Mitigation Fees	$9.5	4%
Gas Tax Subvention	$4.6	2%
Other Local	$25.5	11%
Total	$225.6 **($260.3)**	**100%**

Table 43: Core State Revenue Over 25 Years (in Nominal Dollars) in Billions

State Programs	Funding	Percent
State Highway Operation and Protection Program	$19.5	41%
State Gasoline Tax Swap	$11.0	24%
State Transportation Improvement Program	$9.4	20%
Prop 1B Bonds	$3.4	7%
State Transit Assistance	$2.8	6%
Other State	$0.8	2%
Total	$46.9 **($54.2)**	**100%**

Table 44: Core National Revenue Over 25 Years (in Nominal Dollars) in Billions

Federal Programs	Funding	Percent
Federal Transit Administration Formula	$14.2	43%
Surface Transportation Program	$6.7	21%
Federal Transit Administration Discretionary	$5.3	16%
Congestion Mitigation and Air Quality	$5.0	15%
Other Federal	$1.8	5%
Total	$33 **($38.1)**	**100%**

SCAG also proposes a number of new potential revenue sources. While this revenue is assumed it is by no means guaranteed. Any future revenue depends on the willingness of politicians and the taxpayers to implement new or different taxes and user fees. The proposed programs comprising the $254 billion in new funding are detailed in the following table.

Table 45: SCAG's New Revenue Sources Over 25 Years (in Nominal Dollars) in Billions		
Program	Government Level	Funding
Local Sales Tax Bond Proceeds	Local	$25.6
State and Federal Gas Excise Tax Adjustment	Federal/State	$16.9
Mileage-Based User Fees	Federal, State	$110.3
Highway Tolls	Local	$22.3
Private Equity Participation	Local	$2.7
Freight Fee/National Freight Program	Federal, State, Local	$4.2
E-Commerce Tax	State	$3.1
Interest Earnings	Local	$0.2
State Bond Proceeds	State	$33.0
Value Capture Strategies	Local	$1.2

There are several problems with this funding strategy. First, before California looks for substantial new revenue or significantly increases taxes, the region should strive to maximize its existing resources. The state is continually ranked in the bottom in terms of highest cost per mile, highest salaries and reluctance to try innovative methods. Second, many of these new revenue sources are unlikely to come to fruition. The federal government is unlikely to both increase the gas tax and enact a new freight fee. It is more likely to be one or the other. The $254 billion figure assumes that all of these transportation tax increases will pass, which is also unlikely. Third, this strategy assumes that all of these new taxes will be added to existing taxes. As a result, the expectation of $606 billion of revenue over 25 years appears extremely unrealistic.

Our mobility plan examines what can be accomplished with the existing $352 billion in current revenue. Given the uncertainty about future federal funding, we believe this is the most prudent course of action.

D. Changes to Transportation Funding and Finance

The following section will present our recommendations on how Southern California can use its existing resources to fund the suggested transportation improvements. Our Southern California Mobility plan, not including tolling, costs $361.9 billion (inflation-adjusted) funding over 25 years. However, since our plan features an extensive network of optional variably priced highway lanes and optional tolled grade separations to bypass the most congested surface street intersections, an additional $32.2 billion is provided through toll revenue. This allows the other funding sources to be stretched further, funding more critically important projects. Table 46 details each component of our plan.

Table 46: Reason Plan Components and Costs (in Nominal Dollars)

Component	Total Cost (nominal)	Cost Covered by Tolls	SCAG Projected Revenue Collection
New surface expressways/tunnels*	$97.2B	$97.2B	$0B
Expressway interchanges reconfiguration	$4.1B	$0B	$4.1B
Arterial/local road capital	$74B	$0B	$74B
Arterial interchange reconstruction	$15.6B	$0B	$15.6B
Express toll lanes	$105.0B	$105.0B	$0B
Express toll lane interchanges	$24.0B	$24.0B	$0B
Managed arterials widening(s)	$16.5B	$16.5B	$0B
Managed arterials optional tolled grade separations	$33.7B	$33.7B	$0B
Managed arterials new alignments	$2.9B	$2.9B	$0B
Contingency	$32.5B	$32.5B	$0B
Transit capital/bus	$42.7B	$0B	$42.7B
Roadway operations and maintenance	$90.5B	$0B	$90.5B
Transit operations and maintenance	$102.4B	$0B	$102.4B
Intelligent transportation systems	$10B	$0B	$10B
Active transportation	$7.7B	$0B	$7.7B
Transportation demand management	$5.2B	$0B	$5.2B
Debt service	$50.1B	$50.1B	$0B
Total	**$714.1B**	**$361.9B**	**$352.2B**

There are significant differences between Reason's plan and SCAG's existing 2012 plan. By using tolling to secure $362 billion in resources, more than half of the plan's total funding, Reason's proposal is able to stretch limited taxpayer resources further and support approximately twice as much investment as SCAG's revenue-constrained plan. Our plan does not have to choose between roadways and transit. It is able to invest significant resources in both.

Reason's funding mechanisms are both more effective and more realistic from a political point of view. Our plan fully funds these improvements with existing resources. It does not require a tax increase. In fact, by using tolls the Reason plan provides more funding without a tax increase than SCAG's plan provides with a tax increase. And since electronic toll lanes and particularly managed arterials traffic forecasts can be challenging to predict, the Reason plan includes a large contingency in case actual traffic counts are lower than projections. By including the congestion reduction components of the SCAG plan, prioritizing the construction of a complete transit network, and including additional projects that reduce congestion, our plan more effectively increases mobility. Table 48 below compares Reason's Plan with SCAG's plan per year. Table 47 compares the plans over the 25-year timeframe.

The Reason plan presents a fiscally conservative method of supporting transportation infrastructure improvements, using tolling to stretch resources further. Combining tolling with existing revenue, our plan provides more resources without a tax increase than SCAG's plan does if all the tax increases are approved.

Table 47: Reason's Plan versus SCAG's Plan Total Funding		
Category	**Reason**	**SCAG***
Roadway Capital Projects (Expressway, Arterial and Local non-tolling)	$93.7B	$102.7B
Toll Projects	$279.3B	$55.6B
Contingency	$32.5B	$0
Transit Capital Projects	$42.7B	$123.3B
Intelligent Transportation Systems	$10.0B	$8.8B
Active Transportation	$7.7B	$7.7B
Transportation Demand Management	$5.2B	$5.2B
Roadway Operations and Maintenance	$90.5B	$89.5B
Transit Operations and Maintenance	$102.4B	$160.7B
Debt Service	$50.1B	$52.0B
Total	**$714.1B**	**$605.5B**

*Uses SCAG's projected revenue with tax increases

Table 48: Reason's Plan versus SCAG's Plan Annual Funding		
Category	**Reason**	**SCAG***
Roadway Capital Projects (Arterial and Local non-tolling)	$3.8B	$4.1B
Toll Projects	$10.9B	$2.2B
Contingency	$1.3B	$0B
Transit Capital Projects	$1.7B	$4.9B
Intelligent Transportation Systems	$0.4B	$0.4B
Active Transportation	$0.3B	$0.3B
Transportation Demand Management	$0.2B	$0.2B
Roadway Operations and Maintenance	$3.6B	$3.6B
Transit Operations and Maintenance	$4.1B	$6.4B
Debt Service	$2.0B	$2.1B
Total	**$28.3B**	**$24.2B**

*Uses SCAG's projected revenue with tax increases

E. Mileage-Based User Fees

The Reason study agrees with SCAG's recommendation to transition from gas taxes to mileage-based user fees (MBUFs) to provide a sustainable long-term source of transportation funds. However, MBUFs should be used to replace—not supplement—gas taxes. While the SCAG study counts on MBUFs for significant funding (which is highly speculative at this point), our proposal calls for significant implementation of per-mile charges in the form of per-mile tolls for large fractions of the proposed new highway capacity. Appendix F includes more details on mileage-based user fees.

Part 12

Conclusions and Recommendations

This report provides a detailed framework for major mobility improvements for the entire Los Angeles metro area. With a lack of mobility remaining the Southern California's largest transportation problem, the region's productivity, economic base and quality of life are threatened by a poorly functioning transportation system.

Southern California is at a crossroads in transportation policy. Implementing the current SCAG LRP will lead to a future of higher taxes with little relief from congestion. The plan would continue to spend large amounts of resources on rail transit while starving bus transit and only marginally increasing transit ridership.

In contrast, we have proposed a comprehensive transportation system consisting of roadway and transit improvements that would reduce congestion and improve mobility far more effectively than the 2012 SCAG plan. Additionally, our plan fully funds these improvements with existing resources. It does not require tax increases. By including and supplementing the congestion reduction components of the SCAG plan and replacing the ineffective transit components with projects that cost-effectively improve transit service, our plan more effectively increases mobility.

Our plan spends $19.7 billion (in nominal dollars) to improve expressway-expressway and expressway-arterial bottlenecks. These targeted funds will reduce congestion at many of the busiest interchanges in the region. Relieving congestion at these interchanges will help reduce delay in the entire corridor and bring more reliability to bus service.

Our plan spends $105 billion (in nominal dollars) building a region-wide network of express toll lanes. All current HOV lanes, which operate with either too few or too many vehicles in them, would be converted to express toll lanes. The remainder of the network would be new construction. Direct express toll-lane-to-toll-lane ramps will be built at major interchanges to allow commuters to avoid congestion. These ramps will allow vehicles to travel on multiple expressways without having to exit the express lanes.

These toll lanes/intersections are completely voluntary. All commuters can continue to use the free general purpose lanes. All toll lanes are HOV conversions or new lanes. No general purpose lanes are converted to toll lanes.

Managed arterials, featuring optional tolled underpasses, are also a vital part of the plan. The plan devotes $33.7 billion to building 559 tolled grade separations on major arterials. It would also spend $16.5 billion widening limited sections of these arterials and converting some parking lanes to travel lanes to maximize throughput on these roadways. Finally, the plan devotes $2.9 billion to missing links on these arterials to ensure each is continuous.

As with toll lanes/interchanges, usage of these managed arterials is completely voluntary. All commuters can continue to travel through arterial intersections at grade for free. Further, some of the managed arterial upgrades will improve mobility even for vehicles that do not use the tolled grade separations.

The six major projects to close gaps in the regional expressway system invest $97.2 billion in current year dollars. These projects provide 681 new lane-miles of priced highway capacity in strategic locations throughout the region. By the year 2035, these projects would save over 1.0 million vehicle-miles traveled every weekday. The projects would generate more than $90 million in net revenue, providing 93% of the total cost of the network and 100% of the operational costs.

Our plan also outlines how to develop a comprehensive regional local bus, limited-stop bus, express bus and BRT network, all of which are critical. The region needs to build on the success of L.A. Metro BRT-lite lines by expanding the network and improving the signal priority system. The region needs to expand the number of express buses, and to more effectively integrate its existing rail services with existing and new bus services. Both express bus and BRT can take advantages of the managed lanes and managed arterials without having to pay tolls in order to decrease travel times and increase reliability. These factors should make the buses even more successful, increasing both ridership and farebox rate of return. Figure 40 presents a full map of our plan.

Increased mobility in Southern California will also require an investment in operations management, particularly active traffic management and Intelligent Transportation Systems. Active traffic management involves signal coordination, ramp metering, speed harmonization and junction control. By optimizing signal length and traffic speeds, active traffic management systems reduce congestion on expressways and surface streets. Most importantly, operations management will smooth traffic flows in the express lanes and reduce congestion on the managed arterials. Additionally, operations management systems, including queue jumps, are some of the most cost-effective transportation improvements.

Figure 40: Map of Reason's Southern California Mobility Plan Elements

The express lanes, the managed arterials and the six gap-closing expressway projects each meets the definition of a "mega-project" (a single project that costs over $500 million). Successfully managing costs and revenues is crucial to the success of such projects. Innovative financing and management strategies are needed to manage the inherent risks in building the system. The two major risks frequently seen with such projects are cost overruns and traffic/revenue shortfalls. The private sector can play a critical role in meeting these needs if contracts and long-term agreements are structured properly through public-private partnerships (PPPs).

Our plan, adjusted for inflation, costs $714.1 billion over 25 years. SCAG's plan, adjusted for inflation, costs $605.5 billion. While SCAG's plan requires significant new funding, our plan improves mobility by using tolling to provide almost half of all revenue and by focusing on needs, not wants. In fact, our plan provides more total revenue without a tax increase than SCAG's plan includes with a tax increase. Most significantly, our plan more effectively improves mobility for all transportation system users.

Congestion is strangling Southern California, destroying its viability as a place to live and work, as well as its position as a major economic center. But as former Transportation Secretary Norm Mineta said, "Congestion is not a scientific mystery, nor is it an uncontrollable force. Congestion results from poor policy choices and a failure to separate solutions that are effective from those that are not." The policy choices recommended in this report would reduce congestion and improve mobility in Southern California. The region must choose if it wants to embark on a different road to fix its transportation solutions or stay on the road to bad congestion, limited mobility and economic problems.

About the Author

Baruch Feigenbaum is assistant director of transportation policy at Reason Foundation a non-profit think tank advancing free minds and free markets. Feigenbaum has a diverse background researching and implementing transportation issues including public-private partnerships, highways, transit, high-speed rail, ports, intelligent transportation systems, land use and local policymaking.

Feigenbaum is involved with various transportation organizations. He is a member of the Transportation Research Board Bus Transit Systems and Intelligent Transportation Systems Committees. He is Vice President of Membership for the Transportation and Research Forum Washington Chapter. Feigenbaum is also a member of the American Planning Association, Institute of Transportation Engineers, and Young Professionals in Transportation. He has appeared on NBC Nightly News and CNBC. His work has been featured in the *Washington Post* and *The Wall Street Journal*.

Prior to joining Reason, Feigenbaum handled transportation issues on Capitol Hill for Representative Lynn Westmoreland. He earned his Master's degree in Transportation from the Georgia Institute of Technology.

Appendix A: Bottleneck Removal

Appendix A is a detailed listing of the components of bottleneck removal. Table A1 lists each of the components of interchange-to-interchange bottleneck improvements and their costs. Table A2 shows the expressway/arterial bottleneck improvements and the cost for each project.

Table A1: Interchange-to-Interchange Bottleneck Projects: Component Costs

Interchange	Movement	Change	Cost
I-10 at I-110	I-110N to I-10W	Eliminate loop	$75M
	I-110N to I-10E	Widen to 2 lanes	$15M
	I-110S to I-10E	Widen to 2 lanes, eliminate loop and extend merge lane	$83.6M
	I-10E to I-110S	Widen to 2 lanes	$20M
	I-10E to I-110N	Widen to 3 lanes, move exit to right side of road	$100M
	I-10W to I-110S	Widen to 2 lanes	$75M
	I-10W to I-110N	Widen to 2 lanes and extend merge lane	$28.6M
I-10 at I-405	I-10W to I-405S	Widen to 2 lanes	$75M
	I-10W to I-405N	Widen to 3 lanes and extend merge lane	$33.6M
	I-10E to I-405S	Widen to 2 lanes	$15M
	I-10E to I-405N	Widen to 2 lanes	$75M
	I-405S to I-10W	Widen to 2 lanes	$15M
	I-405S to I-10E	Widen to 3 lanes	$95M
	I-405N to I-10W	Widen to 2 lanes	$75M
	I-405N to I-10E	Widen to 2 lanes	$15M
	I-10W between I-405 and SR 1S	Add 1 lane	$51.3M
	I-10E between I-405 and SR 1S	Add 1 lane	$56.5M
I-5 at I-10, US 101 and SR 60	I-5N to I-10W	Widen to 2 lanes, move merge to right side	$85M
	I-10W merge with I-5N	Move to right side of highway	$90M
	I-5N between I-10W off-ramp and I-10E off-ramp	Add 1 lane	$17M
	I-5S between I-10E on-ramp and I-10W off-ramp	Add 1 lane	$17M
	I-5S to SR 60E	Widen to 2 lanes, move merge to right side	$75M
	I-10W to I-5N	Widen to 3 lanes	$25M
	I-10E to I-5S	Widen to 3 lanes, move merge to right side	$45M
	SR 60W to I-5N	Widen to 2 lanes	$25M
	I-10/US 101 Conn from US101 to I-5	Add 1 lane in each direction	$17M
US 101 at SR 110	SR 110N to US 101N	Widen to 3 lanes	$95M
	US 101S to SR 110S	Widen to 2 lanes	$23.6M
I-405 at US 101	I-405N to US 101N	Widen to 3 lanes, move merge to right side	$115M
	US 101S to I-405S	Widen to 3 lanes	$35M
I-5 at I-605	I-5S to I-605S	Widen to 3 lanes and extend merge	$47.1M
	I-5S to I-605N	Widen to 2 lanes, eliminate loop	$75M
	I-5N to I-605S	Widen to 2 lanes, eliminate loop	$75M
	I-5N to I-605N	Widen to 2 lanes and extend merge	$42.1M
	I-605N to I-5N	Widen to 3 lanes	$95M
I-5 at I-710	I-710N to I-5N	Widen to 3 lanes, move merge to right	$95M
	I-5S to I-710S	Widen to 3 lanes	$25M
I-10 at I-605	I-10W to I-605S	Widen to 3 lanes, extend merge and move it to the right	$103.6M
	I-10E to I-605N	Widen to 2 lanes, eliminate loop	$75M
	I-605N to I-10E	Widen to 3 lanes	$25M
	I-605N to I-10W	Eliminate loop	$75M
	I-605S to I-10W	Widen to 2 lanes and extend merge	$23.6M
I-605 at SR 60	I-605N to SR 60W	Eliminate loop	$75M
	I-605N to SR 60E	Widen to 3 lanes	$25M
	I-605S to SR 60W	Widen to 3 lanes	$25M
	I-605S to SR 60E	Widen to 2 lanes, eliminate loop	$75M

Table A1: Interchange-to-Interchange Bottleneck Projects: Component Costs

Interchange	Movement	Change	Cost
	SR 60W to I-605S	Widen to 2 lanes	$10M
	SR 60W to I-605N	Widen to 3 lanes	$95M
	SR 60E to I-605S	Widen to 3 lanes	$95M
I-5 at SR 55	I-5S to SR 55S	Widen to 3 lanes	$25M
	I-5N to SR 55N	Widen to 3 lanes	$25M
	I-5N to SR 55S	Widen to 2 lanes, eliminate loop	$75M
	SR 55S to I-5S	Widen to 3 lanes and extend merge	$112.1M
	SR 55N to I-5N	Widen to 3 lanes and extend merge	$112.1M
Total			$3.07B

Table A2: New and Modified Expressways and Interchanges

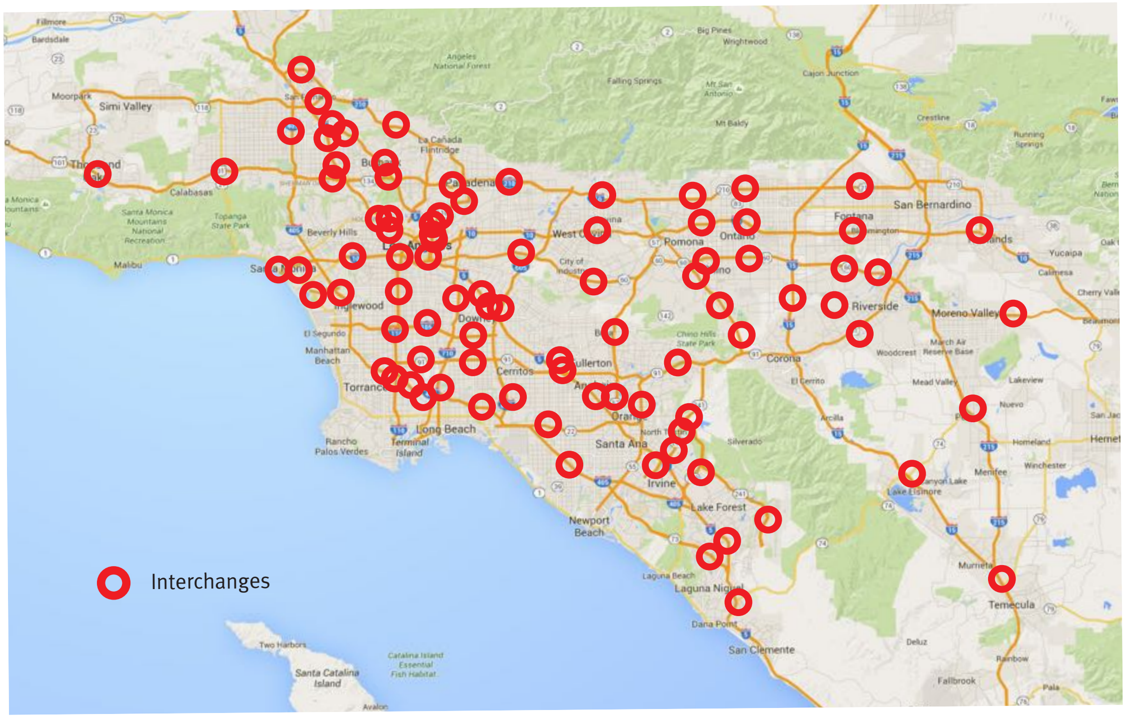
Interchange	Cost
Roscoe Blvd at I-405	$160 M
Roscoe Blvd at SR 170	$12M
Tuxford Rd at I-5	$144M
La Tuna Canyon Rd at I-210 Interchange	$120M
Santa Monica Blvd at US 101 Interchange	$160M
Sunset Blvd at SR 110 Interchange	$24M
Grevelia St at SR 110/Fair Oaks Ave	$40M
SR 90 at Mindanao Way	$48M
Slauson Ave at I-110	$160M
Slauson Ave at I-710	$208M
Slauson Ave at I-5	$160M
Telegraph Rd at I-605	$120M
Imperial Highway at SR 57	$80M
Chino Hills Parkway at SR 71	$160M
Limonite Ave at I-15	$160M
Riverview Dr at SR 60	$104M
Carson St at I-110	$160M
Carson St at I-405	$160M
Carson St at I-710	$208M
Carson St at I-605	$80M
Ball Rd at I-5	$196M
Ball Rd at SR 57	$80M
Taft Ave at SR 55	$208M
Santiago Canyon Rd at SR 241/SR 261	$40M
Warner Ave at I-405	$80M
Warner Ave at SR 55	$208M
Edinger Ave at Tustin Ranch Rd	$52M
Tustin Ranch Rd at I-5	$160M
Portola Parkway at SR 261	$160M
Portola Parkway at SR 133	$160M
Alicia Parkway at SR 73	$208M
Alicia Parkway at I-5	$80M
Santa Margarita Parkway at SR 241	$132M
SR 74 at I-5	$120M
SR 74 at I-15	$160M
SR 74W at I-215	$40M
SR 23S at US 101	$80M
SR 1 at SR 90	$80M
SR 1S at I-10	$80M
SR 27 at US 101	$12M
La Cienega Blvd at I-405	$52M
La Cienega Blvd at I-10	$160M
Laurel Canyon Blvd at US 101	$160M
Laurel Canyon Blvd at SR 170	$196M
Laurel Canyon Blvd at I-5	$160M
San Fernando Blvd at SR 118	$160M
Alameda St at I-405	$208M

Table A2: New and Modified Expressways and Interchanges

Interchange	Cost
Alameda St at SR 91	$144M
Alameda St at I-105	$208M
Alameda St at I-10	$208M
Alameda St at US 101	$208M
Broadway at I-5	$160M
Pasadena Ave at SR 110	$208M
Figueroa St at SR 134	$12M
Lakewood Blvd at SR 91	$80M
Lakewood Blvd at I-105	$112M
Lakewood Blvd at I-5	$80M
Rosemead Blvd at SR 60	$80M
Rosemead Blvd at I-210	$208M
Western Ave at I-405	$116M
Western Ave at I-105	$208M
Western Ave at I-10	$160M
Western Ave at US 101	$196M
Buena Vista St at SR 134	$172M
Buena Vista St at I-5	$144M
Glen Oaks Blvd at SR 118	$208M
Glen Oaks Blvd at I-210	$110M
Beach Blvd at SR 22	$80M
Beach Blvd at SR 91	$80M
Beach Blvd at I-5	$144M
Azusa Ave at SR 60	$80M
Azusa Ave at I-10	$80M
Azusa Ave at I-210	$80M
Fairmont Blvd at SR 91	$158M (includes bridge)
Peyton Dr at SR 71	$172M
Towne Ave at SR 60	$208M
Towne Ave at I-10	$160M
Towne Ave at I-210	$80M
Euclid Ave at SR 71	$40M
Euclid Ave at SR 60	$160M
Euclid Ave at I-10	$132M
Euclid Ave at I-210	$208M
Van Buren Blvd at SR 91	$132M
Van Buren Blvd at SR 60	$132M
Van Buren Blvd at Limonite Ave	$12M
Sierra Ave at I-10	$160M
Sierra Ave at I-210	$40M
SR 79 at I-15	$40M
Theodore St at SR 60	$52M
Tennessee St at I-10/I-210	$192M
SR 1 at San Vicente Rd	$104M
Total	**$11.6B**

Note: Current figures are in 2015 numbers. This table breaks down the projects. Some will be completed in 2020 while others may not happen until 2035. As a result there is no point in converting them all to nominal because it won't make the totals any more accurate than if they are in 2015 numbers.

Figure A1: Map of Improved Interchanges



Appendix B: Express Lane Details

Appendix B begins by delineating each of the components in the express lane network additions and conversions as well as the express lane-express lanes ramps. Table B1 lists the new lanes that need to be added to the network and the current HOV lanes that need to be converted to express lanes. Table B2 lists each of the expressway-expressway lane ramps needed. Both tables show the location of the interchange, the scope of work, and cost.

This is followed by a detailed explanation of how we arrived at and how we calculated the costs for building the express lane network and the revenue collected from the express lane tolling.

Then we address express lanes revenue and costs. Table B3 provides the revenue and Table B4 shows the cost. Both of the spreadsheets used to calculate express lane figures are included in these two tables.

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
Los Angeles, Orange	I-5	San Diego North County Line	Camino Capistrano Rd	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (7.5) 15.0 lm	$269.3M
		Camino Capistrano Rd	San Juan Creek Rd	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (1.2) 4.8 lm	$84.9M
		San Juan Creek Rd	Crown Valley Parkway	Add 1 HOT lane in each direction and convert HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (5.1) 2 exs ln (5.1) 20.4 lm	$266.2M
		Crown Valley Parkway	I-405 North	Add 2 HOT lanes in each direction and convert HOV lanes to HOT lanes (6 HOT lanes total)	4 new ln (7.5) 2 exs ln (7.5) 45.0 lm	$648M
		I-405 North	SR 261/Jamboree Rd	Add 1 HOT lane in each direction and convert HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (6.1) 2 exs ln (6.1) 24.4 lm	$476M
		SR 261/Jamboree Rd	SR 22/SR 57	Add 2 HOT lanes in each direction and convert HOV lanes to HOT lanes (4 HOT lanes total)	4 new ln (6.7) 2 exs ln (6.7) 40.2 lm	$779.2M
		SR 22/SR 57	SR 39	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (9.4) 2 exs ln (9.4) 37.6 lm	$740M
		SR 39	Artesia Blvd	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (0.9) 3.6 lm	$83.9M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
		Artesia Blvd	Florence Ave	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (6.5) 2 new ln (6.5) 26.0 lm	$507M
		Florence Ave	SR 134	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (20.6) 82.4 lm	$2,027M
		SR 134	Alameda Ave	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (4.5) 2 exs ln (4.5) 18.0 lm	$351M
		Alameda Ave	Brand Blvd	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (11.6) 46.4 lm	$923.3M
		Brand Blvd	I-405	Convert existing HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (1.6) 3.2 lm	$27.7M
		I-405	SR 14	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (3.8) 2 exs ln (3.8) 15.2 lm	$198.4M
		SR 14	SR 126 West	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (9.8) 18.6 lm	$333.4M
Los Angeles San Bernardino	I-10	SR 1 North	New Tolled Tunnel/ Lincoln Blvd	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (0.8) 1.6 lm	$28.7M
		New Tolled Tunnel/ Lincoln Blvd	I-405	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (3.3) 13.2 lm	$324.8M
		I-405	Crenshaw Blvd	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (5.9) 23.6 lm	$580.6M
		Crenshaw Blvd	Hoover St	Add 3 HOT lanes in each direction (6 HOT lanes total)	6 new ln (2.9) 17.4 lm	$340.6M
		Hoover St	I-5 South	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (4.0) 16.0 lm	$393.6M
		I-5 North	Puente Ave	Add 1 HOT lane in each direction (4 HOT lanes total)	2 new ln (14.9) 2 exs ln (14.9) 59.6 lm	$1,160.6M
		Puente Ave	SR 57/SR 71	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (9.2) 36.8 lm	$905.3M
		SR 57/SR 71	I-215	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (29.8) 2 exs ln (29.8) 119.2 lm	$2,175.4M
		I-215	SR 38 North	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (6.6) 26.4 lm	$467.3M
		SR 38 North	Indio Blvd	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (60.4) 120.8 lm	$2,168.4M
Riverside San Bernardino	I-15	SR 79 South	SR 79 North	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (3.2) 6.4 lm	$114.9M
		SR 79 North	I-215 North	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (2.0) 8.0 lm	$141.6M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
		I-215 North	Cajalco Rd	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (28.1) 56.2 lm	$1,008.8M
		Cajalco Rd	SR 60	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (14.7) 58.8 lm	$1,040.8M
		SR 60	I-210	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (9.0) 36.0 lm	$886M
		I-210	I-215	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (8.3) 16.6 lm	$298M
		I-215	SR 138	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (7.4) 29.6 lm	$523.9M
		SR 138	SR 18 East	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (20.3) 40.6 lm	$728.8M
Los Angeles	I-105	SR 1	I-405	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (1.6) 3.2 lm	$57.4M
		I-405	I-110	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (5.4) 2 exs ln (5.4) 21.6 lm	$281.9M
		I-110	I-710	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (7.4) 2 exs ln (7.4) 29.6 lm	$565.4M
		I-710	I-605	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (4.3) 2 exs ln (4.3) 17.2 lm	$224.5M
Los Angeles	I-110	Anaheim St	I-405	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (5.5) 11.0 lm	$197.5M
		I-405	½ mi. N of SR 91	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (1.3) 5.2 lm	$127.9M
		1/2 mi. S of I-10	US 101	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (2.5) 10 lm	$246M
		US 101	York Boulevard	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (5.7) 11.4 lm	$283.3M
Los Angeles, San Bernardino	I-210	I-5	I-710	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new (24.9) 49.8 lm	$894M
		I-710	SR 57	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (19.7) 2 exs lan (19.7) 78.8 lm	$1,537M
		SR 57	I-215	Covert 1 HOV lane in each direction to HOT lane (2 HOT lanes total)	2 exs lan (29.5) 59.0 lm	$510.4M
		I-215	I-10	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (11.2) 22.4 lm	$402.1M
Riverside San Bernardino	I-215	I-15	SR 60 East	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (29.5) 59.0 lm	$1,059.1M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
		SR 60 East	SR 60 West	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 new ln (5.2) 2 exs ln (5.2) 20.8 lm	$405.6M
		SR 60 West	Orange Show Rd	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (7.1) 28.4 lm	$698.7M
		Orange Show Rd	SR 259	Convert 1 HOV lane in each direction to HOT lane (2 HOT lanes total)	2 exs ln (3.5) 7.0 lm	$60.6M
Orange, Los Angeles	I-405	I-5	SR 73	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (10.0) 2 new ln (10.0) 40.0 lm	$522M
		SR 73	Brookhurst St	Add 2 HOT lanes in each direction, covert existing HOV lanes to HOT lanes (6 HOT lanes total)	2 exs ln (3.5) 4 new ln (3.5) 21.0 lm	$395.9M
		Brookhurst St	SR 22 East	Add 1 HOT lane in each direction, covert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (7.0) 2 new ln (7.0) 28.0 lm	$542.5M
		SR 22 East	I-605	Add 2 HOT lanes in each direction, convert existing HOV lanes to HOT lanes (6 HOT lanes total)	2 exs ln (3.2) 4 new ln (3.2) 19.2 lm	$366.1M
		I-605	Rosecrans Ave	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (19.2) 2 new ln (19.2) 76.8 lm	$1,482.2M
		Rosecrans Ave	Wilshire Blvd	Add 2 HOT lanes in each direction, convert existing HOV lanes to HOT lanes (6 HOT lanes total)	2 exs ln (12.4) 4 new ln (12.4) 74.4 lm	$1,422.3M
		Wilshire Blvd	SR 118	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (15.3) 2 new ln (15.3) 61.2 lm	$1,193M
		SR 118	I-5	Convert 1 HOV lane in each direction to HOT lane (2 HOT lanes total)	2 exs ln (1.8) 3.6 lm	$31M
Los Angeles, Orange	I-605	I-405	I-10	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (21.8) 2 new ln (21.8) 87.2 lm	$1,700M
		I-10	I-210	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (5.6) 22.4 lm	$551M
Los Angeles	I-710	Pico Avenue	Shoreline Dr	Add 2 TOT lanes in each direction (4 TOT lanes)	4 new ln (0.9) 3.6 lm	$63.7M
		Shoreline Dr	Anaheim St	Add 1 HOT lane in each direction (2 HOT lanes)	2 new ln (0.3) 0.6 lm	$10.7M
		Anaheim St	I-405	Add 1 HOT lane and 1 GP lane in each direction 2 HOT lanes, 2 GP lanes)	4 new ln (3.0) 12 lm	$214.5M
		I-405	SR 60	Add 2 HOT lanes in each direction (4 HOT lanes)	4 new ln (15.2) 60.8 lm	$1,145.7M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
		SR 60	I-10	Add 1 HOT lane in each direction (2 HOT lanes)	2 new ln (1.9) 3.8 lm	$93.8M
		I-10	New Tunnel	Add 1 HOT lane in each direction (2 HOT lanes)	2 new ln (1.0) 2 lm	$49.5M
		New Tunnel	I-210	Add 1 HOT lane in each direction (2 HOT lanes)	2 new ln (0.7) 1.4 lm	$34.8M
Los Angeles, Ventura	US 101	I-5	I-10	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (1.8) 3.6 lm	$111.1M
		I-10	I-405	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (17.2) 68.8 lm	$1,692.5M
		I-405	Tampa Ave	Add 3 HOT lanes in each direction (6 HOT lanes total)	6 new ln (5.1) 30.6 lm	$750.2M
		Tampa Ave	Wendy Dr.	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (25.8) 103.2 lm	$2,538.7M
		Wendy Dr.	SR 33	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (23.0) 46.0 lm	$825.7M
Los Angeles	SR 2	Glendale Blvd	I-210/SR 510	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (8.9) 17.8 lm	$319.5M
Los Angeles	SR 14	I-5	Ave P-8	Convert 1 HOV lane in each direction to a HOT lane (2 HOT lanes total)	2 exs ln (35.8) 71.6 lm	$619.3M
		Ave P-8	Ave L	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (5.0) 10.0 lm	$86.5M
Orange	SR 22	I-405	SR 55	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (12.7) 2 new ln (12.7) 50.8 lm	$1,264.9M
Orange	SR 55	19th St	I-405	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (4.0) 8.0 lm	$143.6M
		I-405	SR 91	Add 1 HOT lane in each direction convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (11.8) 2 new ln (11.8) 47.2 lm	$920M
Orange, Los Angeles	SR 57	I-5	SR 60 West	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (16.2) 2 new ln (16.2) 64.8 lm	$1,264M
		SR 60 East	I-10	Covert HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (3.2) 6.4 lm	$55.4M
		I-10	I-210	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (4.1) 2 new ln (4.1) 16.4 lm	$319.8M
Los Angeles, San Bernardino	SR 60	I-10	SR 57 South	Add 1 HOT lane in each direction, convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (22.8) 2 new ln (22.8) 91.2 lm	$1,778M
		SR 57 South	SR 57 North	Add 2 HOT lanes in each direction, covert existing HOV lanes to HOT lanes (6 HOT lanes total)	2 exs ln (1.9) 4 new ln (1.9) 11.4 lm	$218M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
		SR 57 North	I-215 North	Add 1 HOT lane in each direction, covert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (26.8) 2 new ln (26.8) 107.2 lm	$2,069M
		I-215 South	Redlands Blvd	Convert HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (7.8) 15.6 lm	$134.9M
Los Angeles, Riverside, San Bernardino	SR 71	SR 91	Butterfield Ranch Rd	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (3.5) 7.0 lm	$125.7M
		Butterfield Ranch Rd	SR 60	Convert existing HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (8.3) 16.6 lm	$143.6M
		SR 60	I-10	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (4.4) 8.8 lm	$271.5M
Orange	SR 73	MacArthur Blvd	SR 55	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (2.7) 10.8 lm	$191.2M
		SR 55	I-405	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (1.2) 2.4 lm	$43.1M
Orange, Riverside	SR 91	I-110	SR 55 South	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (27.2) 2 new ln (27.2) 108.8 lm	$2,121.6M
		SR 55 South	SR 90	Add 1 HOT lane in each direction (6 HOT lanes total)	2 exs ln (2.4) 4 exs ln (2.4) 14.4 lm	$275.2M
		SR 90	I-15	2 HOT lanes in each direction	4 exs ln (14.9) 59.6 lm	$1,466.2M
		I-15	Van Buren Blvd	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (6.6) 2 new ln (6.6) 26.4 lm	$514.8M
		Van Buren Blvd	I-215	Add 2 HOT lanes in each direction (4 HOT lanes total)	4 new ln (7.6) 30.4 lm	$419.7M
Ventura, Los Angeles	SR 118	First St	Los Angeles County Line	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (8.7) 17.4 lm	$312.3M
		Los Angeles County Line	Porter Ranch Rd	Convert existing HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (3.8) 7.6 lm	$65.8M
		Porter Ranch Rd	I-5	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (7.6) 2 new ln (7.6) 30.4 lm	$501.6M
		I-5	I-210	Add 1 HOT lane in each direction (2 HOT lanes total)	2 new ln (2.5) 5.0 lm	$171.1M
Los Angeles	SR 134	US 101	SR 2	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (8.9) 2 new ln (8.9) 35.6 lm	$694.2M
		SR 2	I-210	Add 1 HOT lane in each direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	2 exs ln (4.4) 2 new ln (4.4) 17.6 lm	$229.7M
Los	SR	US 101	Roscoe Blvd	Add 1 HOT lane in each	2 exs ln	$405.6M

Table B1: Major Express Lane Additions

County	Route	From	To	Scope	Lane- Miles	Cost
Angeles	170			direction and convert existing HOV lanes to HOT lanes (4 HOT lanes total)	(5.2) 2 new ln (5.2) 20.8 lm	
		Roscoe Blvd	I-5	Convert existing HOV lanes to HOT lanes (2 HOT lanes total)	2 exs ln (0.8) 1.6 lm	$49.4M
Express Lanes Total						$60.3B

Table B2: Truck Toll Lanes

County	Route	From	To	Scope	Lane- Miles	Cost
Los Angeles, San Bernardino	I-710, SR 60, I-15	Pico Ave	I-10	Add 2-4 TOT (truck-only tollway) lanes in each direction	2-4 new ln (50.8) 246.6 lm	$12.6B

Table B3: Interchange Movements

County	Route	Interchange	New Interchange Movements	Existing Motions	Cost
Los Angeles, Orange	I-5	SR 73	I-5N to SR 73N, SR 73S to I-5S	None	$90M
		I-405	None	I-5N to I-405N, I-405S to I-5S	$90M
		SR 133	I-5N to SR 133N, SR 133S to I-5S	None	$90M
		SR 261	I-5N to SR 261N, SR 261S to I-5S	None	$90M
		SR 55	I-5N to SR 55N, SR 55S to I-5S, I-5S to SR 55S	SR 55N to I-5N	$135M
		SR 57	SR 57N to I-5N, I-5S to SR 57S, SR57S to I-5S, I-5N to SR 57N, SR 22W to SR 57N, SR 22E to SR 57N, SR 57S to SR 22W, SR 57S to SR 22E		$360M
		SR 91	None	I-5N to SR 91W, SR 91E to I-5S, I-5S to SR 91E, SR 91W to I-5N	N/A
		I-605	I-5N to I-605N, I-5S to I-605S, I-605N to I-5N, I-605S to I-5S	None	$180M
		I-710	I-5N to I-710N, I-5S to I-710S, I-710N to I-5N, I-710S to I-5S, I-5GPS to I-710TOTS, I-710TOTN to I-5GPN	None	$270M
		I-10W, US 101N, SR 60E	I-5N to US101N, SR 60W to US101N, US101S to SR 60E, US101S to I-5S, I-10E to I-5N, I-10E to I-5S, I-5N to I-10W, I-5S to I-10W, I-5S to SR 60E, SR 60W to I-5N		$450M
		I-10E	I-5N to I-10E, I-10W to I-5S, I-5S to I-10E, I-10W to I-5N		$180M
		SR 110	I-5N to SR 110N, SR 110S to I-5S, I-5S to SR 110S, SR110N to I-5N		$180M
		SR 2	I-5N to SR 2N, SR 2S to I-5S, I-5S to SR 2S, SR 2N to I-5N		$180M
		SR 134	I-5N to SR 134W, SR 134E to I-5S, I-5S to SR 134E, SR 134W to I-5N		$180M
		SR 170	I-5S to SR 170S, SR 170N to I-5N		$90M
		SR 118	I-5S to SR 118E, I-5N to SR 118E, I-5N to SR 118W, SR 118E to I-5S, SR 118W to I-5N, SR 118E to I-5S		$270M
		I-405	I-5S to I-405S, I-405N to I-5N		$90M
		I-210	I-5S to I-210E, I-210W to I-5N		$90M
Los Angeles, Riverside, San Bernardino	I-10	SR 910	I-10W to Tunl N, Tunl S to I-10E		$90M
		I-405	I-10E to I-405S, I-10E to I-405N, I-10W to I-405S, I-10W to I-405N, I-405S to I-10E, I-405S to I-10W, I-405N to I-10E, I-405N to I-10W		$360M
		SR 410	I-10W to SR 410N, I-10W to SR 410S, I-10E to SR 410N, I-10E to SR 410S, SR 410N to I-10W, SR 410N to I-10E, SR 410S to I-10W, SR 410S to I-10E		$360M

Table B3: Interchange Movements

County	Route	Interchange	New Interchange Movements	Existing Motions	Cost
		I-110	I-10E to I-110N, I-10E to I-110S, I-10W to I-110N, I-10W to I-110S, I-110N to I-10E, I-110N to I-10W, I-110S to I-10E, I-110S to I-10W		$360M
		I-710	I-10E to I-710S, I-710N to I-10W, I-10W to I-710S, I-10W to I-710N, I-710N to I-10E, I-710S to I-10E	I-710S to I-10W, I-10E to I-710N	$270M
		I-605	I-10E to I-605N, I-10E to I-605S, I-10W to I-605N, I-10E to I-605S, I-605S to I-10E, I-605N to I-10W, I-605N to I-10E, I-605S to I-10W		$360M
		SR 57, SR 71	I-10E to SR 57N, I-10W to SR 57S, I-10E to SR 71S, I-10W to SR 57N, I-10W to SR 57S, SR 71N to I-10W, SR 71N to SR 57N, SR 57S to I-10E, SR 57S to I-10W, SR 57S to SR 71S, SR 57N to I-10E, SR 57S to I-10W		$540M
		I-15	I-10E to I-15N, I-10E to I-15S, I-10W to I-15N, I-10W to I-15S, I-15N to I-10E, I-15N to I-10W, I-15S to I-10E, I-15S to I-10W		$360M
		I-215	I-10E to I-215N, I-10E to I-215S, I-10W to I-215N, I-10W to I-215S, I-215N to I-10E, I-215N to I-10W, I-215S to I-10E, I-215N to I-10W		$360M
		I-210	I-10W to I-210N, I-210S to I-10E		$90M
Riverside, San Bernardino	I-15	I-215N	I-15N to I-215N, I-215S to I-15S		$90M
		SR 133Ext	I-15N to SR 133W, I-15S to SR 133W, SR 133E to I-15N, SR 133E to I-15S		$180M
		SR 91	I-15N to SR 91W, I-15N to SR 91E, I-15S to SR 91W, I-15S to SR 91E, SR 91E to I-15N, SR 91E to I-15S, SR 91W to I-15N, SR 91E to I-15S		$360M
		SR 60	I-15N to SR 60E, I-15N to SR 60W, I-15S to SR 60E, I-15S to SR 60W, SR 60E to I-15N, SR 60E to I-15S, SR 60W to I-15N, SR 60W to I-15S		$360M
		SR 210	I-15N to SR 210E, I-15N to SR 210W, I-15S to SR 210W, SR 210E to I-15N, SR 210E to I-15S, SR 210W to I-15S		$360M
		I-215S	I-15S to I-215S, I-215N to I-15N		$90M
		SR 315	I-15N to SR 315W, I-15S to SR 315W, SR 315E to I-15N, SR 315E to I-15S		$180M
Los Angeles	I-105	I-405	I-105W to I-405N, I-105W to I-405S, I-105E to I-405N, I-105E to I-405S, I-405N to I-105E, I-405N to I-105W, I-405S to I-105E, I-405S to I-105W		$360M
		I-110	I-105E to I-110S, I-105W to I-110S, I-110N to I-105E, I-110N to I-105W		$180M
		I-710	I-105E to I-710N, I-105E to I-710S, I-105W to I-710N, I-105W to I-710s, I-710N to I105E, I-710N to I-105W, I-710S to I-105E, I-710S to I-105W		$360M
		I-605	I-105E to I-605N, I-105E to I-605S, I-605N to I-105W, I-605S to I-105E		$180M
Los Angeles	I-110	I-405	I-110N to I-405S, I-110N to I-405N, I-110S to I-405N, I-110S to I-405S, I405N to I-110N, I-405S to I-110N, I-405N to I-110S, I -405S to I-110S		$360M
		SR 91	I-110N to SR 91E, I-110S to SR 91E, SR 91W to I-110N, SR 91W to I-110S		$180M
		SR 410	I-110N to SR 410N, SR 410S to I-110S		$90M
		US 101	I-110N to US 101N, I-110N to US 101S, I-110S to US 101N, US 101S to I-110N, US 101S to I-110S, US 101S to I-110N		$270M
Los Angeles, San Bernardino	I-210	SR 118	I-210W to SR 118W, SR 118E to I-210E		$90M
		SR 2	I-210E to SR 2S, I-210E to SR 510N, I-210W to SR 510N, SR 2N to I-210W, SR 510S to I-210E, SR 510S to I-210W		$270M
		I-710	I-210E to I-710S, I-210E to I-710N, I-210W to I-710N, I-210W to I-710S, I-710N to I-210E, I-710N to I-210W, SR 134E to I-710S SR 134E to I-210W		$360M
		I-605	I-210E to I-605S, I-210W to I-605S, I-605N to I-210E, I-605N to I-210W		$180M
		SR 57	I-210E to SR 57S, I-210W to SR 57S, SR 57N to I-210E, SR 57N to I-210W		$180M
		I-215	SR 210E to I-215S, SR 210W to I-215N, I-215N to SR 210W, I-215S to SR 210E		$180M
Riverside, San Bernardino	I-215	SR 60E	I-215N to I-215N, I-215S to I-215S, I-215N to SR 60E, SR 60W to I-215S		$180M
		SR 60W, SR 91	I-215N to I-215N, I-215N to SR 91W, SR 60E to I-215N, SR 91E to I-215S, I-215S to I-215S, I-215S to SR 60W		$270M
Los Angeles, San Bernardino	SR 315	SR 14	SR 14N to SR 315E, SR 14S to SR 315E, SR 315W to SR 14N, SR 315W to SR 14S		$180M
Orange, Los Angeles	I-405	SR 55	I-405N to SR 55S, SR 55N to I-405S,	I-405N to SR 55N, I-405S to SR 55N, SR 55S to I-405N, SR 55S to I-405S	$90M
		SR 57 Ext	I-405N to SR 57N, I-405S to SR 57N, SR 57S to I-405N, SR 57S to I-405S		$180M
		SR 73	I-405S to SR 73S, SR 73N to I-405N		$90M
		SR 22	I-405S to SR 22E, SR 22W to I-405N		$90M
		I-605	I-405N to I-605N, I-405S to I-605N, I-605S to I-405S, I-605S to I-405N		$180M
		I-710	I-405S to I-710N, I-405S to I-710S, I-405N to I-710N, I-405N to I-710S, I-710S to I-405N, I-710S to I-405S, I-710N to I-405N, I-710N to I-405S, I-405N to I-710S, I-405S to I-710S, I-710N to I-405S, I-710N to I-405N		$540M
		US 101	I-405N to US 101S, I-405N to US 101N, I-405S to US 101N, I-405S to US 101S, US 101N to I-405N, US 101N to I-405S, US 101S to I-405N, US 101S to I-405S		$360M
		SR 118	I-405N to SR 118E, I-405N to SR 118W, I-405S to SR 118W, SR 118E to I-		$270M

Table B3: Interchange Movements					
County	Route	Interchange	New Interchange Movements	Existing Motions	Cost
			405N, SR 118E to I-405S, SR 118W to I-405S		
Los Angeles	SR 410	US 101	SR 410N to US 101N, SR 410N to US 101S, SR 410S to US 101N, SR 410S to US 101S, US 101N to SR 410N, US 101N to SR 410S, US 101S to SR 410N, US 101S to SR 410S		$360M
Los Angeles	SR 510	SR 14	SR 510N to SR 14S, SR 510N to SR 14N, SR 14S to SR 510S, SR 14N to SR 510S		$180M
Orange, Los Angeles	I-605	SR 91	I-605N to SR 91W, I-605N to SR 91E, I-605S to SR 91W, I-605S to SR 91E, SR 91W to I-605N, SR 91W to I-605S, SR 91E to I-605N, SR 91E to I-605S		$360M
		SR 60	I-605N to SR 60W, I-605N to SR 60W, I-605S to SR 60W, I-605S to SR 60E, SR 60W to I-605N, SR 60W to I-605N, SR 60E to I-605N, SR 60E to I-605S		$360M
Los Angeles	I-710	SR 91	I-710N to SR 91W, I-710N to SR 91E, I-710S to SR 91W, I-710S to SR 91E, I-SR 91W to I-710N, SR 91W to I-710S, SR 91E to I-710N, SR 91E to I-710S		$360M
		SR 60	I-710N to SR 60E, I-710S to SR 60W, I-710S to SR 60E, SR 60W to I-710N, SR 60E to I-710N, SR 60E to I-710S		$270M
Los Angeles	SR 910	US 101	SR 910N to US 101N, SR 910N to US 101S, US 101N to SR 910S US 101S to SR 910S		$180M
Los Angeles, Ventura	US 101	SR 134, SR 170	US 101N to US 101N, US101S to US 101S, SR 134W to SR 170N, SR 170S to SR 134E		$180M
		SR 126	US101S to SR 126WGP, SR 126EGP to US 101N		$90M
Los Angeles	SR 2	SR 134	SR 2N to SR 134W, SR 2N to SR 134E, SR 2S to SR 134W, SR 2S to SR 134E, SR 134W to SR 2N, SR 134W to SR 2S, SR 134E to SR 2N, SR 134E to SR 2S		$360M
Orange	SR 22	SR 55	SR 22E to SR 57N, SR 22E to SR 57S, SR 57N to SR 22W, SR 57S to SR 22W		$180M
Orange	SR 55	SR 73	SR 55N to SR 73S, SR 55N to SR 73N, SR 55S to SR 73S, SR 73N to SR 55N, SR 73N to SR 55S, SR 73S to SR 55S		$270M
		SR 91	SR 55N to SR 91E, SR 91W to SR 55S, SR 55N to SR 91W, SR 91E to SR 55S		$180M
Los Angeles, Orange	SR 57	SR 91	SR 57N to SR 91W, SR 57N to SR 91E, SR 57S to SR 91E, SR 91W to SR 57N, SR 91W to SR 57S, SR 91E to SR 57S	SR 57S to SR 91W, SR 91E to SR 57N	$270M
		SR 60W	SR 57N to SR 60W, SR 57N to SR 60E, SR 60W to SR 57S, SR 60E to SR 57S		$180M
		SR 60E	SR 57S to SR 60W, SR 60E to SR 57N		$90M
Los Angeles, Riverside, San Bernardino	SR 60	SR 71	SR 60W to SR 71S, SR 60E to SR 71N, SR 60E to SR 71S, SR 71N to SR 60W, SR 71N to SR 60W, SR 71S to SR 60E		$270M
Los Angeles, Riverside, San Bernardino	SR 71	SR 91	SR 71GPS to SR 91E, SR 71SGP to SR 91W, SR 91E to SR 71GPN, SR 91W to SR 71GPN		$180M
Total					$17.8B

1. Estimating Express Lane Toll Traffic and Revenue

The process for estimating express lane toll traffic and revenue requires several steps. First we will focus on calculating the likely toll rate. Since the SR 91 express lanes in Orange County have been operating for 20 years, the lanes provide a great starting point for calculating tolls. SR 91 operates with seven peak hours per weekday, 6 to 9 AM and 3 to 7 PM. The average weekday toll rate in the peak direction during the AM peak is $4.82 and during the PM peak it is $6.07. Since the facility is 10 miles long, the rate per mile is the total toll divided by 10. Thus, the simple average peak-direction toll rate during the seven weekday peak hours is $.553 per mile.

Our basic model computes the toll revenue produced per lane-mile of express lanes during the peak hours on a weekday. We make the following assumptions in doing this:

- The average toll charged on an express lane in the *non-peak* direction is 41% of the peak-direction toll rate (based on data from the 91 Express Lanes).
- The volume of traffic in the peak direction during peak periods is 1,600 *paying* vehicles/lane/hour (which also allows for up to 100 *non-paying* vehicles, such as buses and vanpools, for a total of 1,700). Given the projected LOS F conditions as of 2035 in every corridor for which we have proposed express lanes, our assumption is that the express lanes would be filled to the maximum traffic level possible during non-congested operation, (*peak periods in the peak direction)*.
- The express lane volume in the *non-peak* direction, paying 41% of the toll rate charged in the peak direction, is assumed to be *half* that of the peak direction, 800 vehicles/lane/hour.
- The number of peak hours in a weekday is currently 7 (3.0 in the AM and 4.0 in the PM. to 8 in 2030 (3.5 in the AM and 4.5 in the PM period), and 9 in 2050 (4.0 in the AM and 5.0 in the PM period.) We adjusted calculations on our spreadsheet accordingly.

Using the above assumptions, we next compute the average weekday toll revenue generated during peak periods. After ramp-up, the weighted average hourly traffic in a managed lane during the seven peak hours is 1,200, and the weighted average toll rate begins at $0.30 in 2020 and increases at the rate of inflation. Hence, for the express lane system, the weekday peak-period revenue in 2044 (after all the managed lanes have been constructed) is $19.0 million. With 250 weekdays per year, the annual peak-period revenue is $4.7 billion.

On the 91 Express Lanes, non-peak weekday revenue plus all weekend revenue equals 29% of peak-period revenue. Hence, the non-peak revenue for the express network can be estimated as $1.4 billion. Thus, total annual revenue in 2044 for the expressway managed lanes network is $6.2 billion in gross revenue (in 2044 dollars). We subtract 15% of the gross revenue for system operations for a total of $5.4 billion in net revenue.

Tables B4 and B5 project revenue over the lifetime of the project—40 years. Since Southern California's managed lane network is extensive, we project building it over 25 years. During the first five years, the first part of the network will be constructed. During the next five years, the next part will be constructed and so on.

Table B6 details the cost of building the network. We calculated the costs of the express lanes by taking the total net revenue over 40 years of $108B and dividing it by the number of years it will take to build the express lane network, 25. Each yearly total is then adjusted to a 2.9% annual inflation rate. The total to build the managed lanes is detailed in the left column and the total to build the expressway-expressway ramps is detailed in the right column.

Table B4: Express Lane Toll Revenue Calculations (in dollars)

Year	Lane-miles	Weekday Peak Vol ETL	Average Peak Toll	Peak Hours	Peak Revenue Weekday	Annual Revenue Weekday	Annual Non-peak Revenue	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2020	646	640	0.30	7.00	867793.92	216948480.00	62915059.20	279863539.20	237884008.32	1.00	237884008.32
2021	646	780	0.31	7.00	1088294.93	272073732.84	78901382.52	350975115.36	298328848.06	0.95	284122712.44
2022	646	920	0.32	7.00	1320855.19	330213796.67	95762001.04	425975797.71	362079428.05	0.91	328416714.79
2023	646	1060	0.33	7.00	1565988.68	391497170.20	113534179.36	505031349.56	429276647.12	0.86	370825307.96
2024	646	1200	0.34	7.00	1824229.08	456057269.59	132256608.18	588313877.77	500066796.10	0.82	411406190.71
2025	1291	920	0.35	7.00	2878268.64	719567159.95	208674476.39	928241636.34	789005390.89	0.78	618206369.25
2026	1291	990	0.36	7.00	3187088.09	796772023.39	231063886.78	1027835910.17	873660523.64	0.75	651938934.18
2027	1291	1060	0.37	7.00	3511398.45	877849612.92	254576387.75	1132426000.67	962562100.57	0.71	684074913.96
2028	1291	1130	0.38	7.00	3851838.47	962959617.37	279258289.04	1242217906.41	1055885220.45	0.68	714664678.98
2029	1291	1200	0.39	7.00	4209070.92	1052267730.56	305157641.86	1357425372.42	1153811566.56	0.64	743757223.44
2030	1937	1013	0.40	8.00	6267769.60	1566942400.25	454413296.07	2021355696.32	1718152341.87	0.61	1054796494.28
2031	1937	1060	0.41	8.00	6748772.97	1687193241.51	489286040.04	2176479281.55	1850007389.32	0.58	1081661005.19
2032	1937	1106	0.42	8.00	7245851.93	1811462982.21	525324264.84	2336787247.05	1986269159.99	0.56	1106028990.85
2033	1937	1153	0.44	8.00	7772827.15	1943206786.82	563529968.18	2506736754.99	2130726241.74	0.53	1129969618.38
2034	1937	1200	0.45	8.00	8324273.17	2081068291.73	603509804.60	2684578096.33	2281891381.88	0.51	1152510209.20
2035	2583	1060	0.46	8.00	10088464.13	2522116031.69	731413649.19	3253529680.88	2765500228.74	0.48	1330252894.80
2036	2583	1095	0.47	8.00	10723799.43	2680949857.81	777475458.77	3458425316.58	2939661519.09	0.46	1346692812.65
2037	2583	1130	0.49	8.00	11387499.79	2846874946.28	825593734.42	3672468680.69	3121598378.59	0.44	1361943032.63
2038	2583	1165	0.50	8.00	12080676.04	3020169011.04	875849013.20	3896018024.24	3311615320.60	0.42	1376044566.69
2039	2583	1200	0.52	8.00	12804479.64	3201119909.72	928324773.82	4129444683.54	3510027981.01	0.40	1389037262.16
2040	3228	1088	0.53	8.00	14932584.15	3733146038.72	1082612351.23	4815758389.95	4093394631.45	0.38	1542757385.84
2041	3228	1116	0.55	8.00	15761068.08	3940267019.86	1142677435.76	5082944455.62	4320502787.28	0.36	1550811486.90
2042	3228	1144	0.56	8.00	16625045.77	4156261442.09	1205315818.21	5361577260.29	4557340671.25	0.34	1557926320.96
2043	3228	1172	0.58	8.00	17525879.10	4381469776.24	1270626235.11	5652096011.35	4804281609.65	0.33	1564136237.07
2044	3228	1200	0.60	8.00	18464979.11	4616244777.90	1338710985.59	5954955763.50	5061712398.97	0.31	1569474586.00
2045	3228	1200	0.61	8.00	19000463.51	4750115876.46	1377533604.17	6127649480.64	5208502058.54	0.30	1538085094.28
2046	3228	1200	0.63	8.00	19551476.95	4887869236.88	1417482078.70	6305351315.58	5359548618.24	0.28	1507323392.40
2047	3228	1200	0.65	8.00	20118469.78	5029617444.75	1458589058.98	6488206503.73	5514975528.17	0.27	1477176924.55
2048	3228	1200	0.67	8.00	20701905.40	5175476350.65	1500888141.69	6676364492.34	5674909818.49	0.26	1447633386.06
2049	3228	1200	0.69	8.00	21302260.66	5325565164.82	1544413897.80	6869979062.61	5839482203.22	0.24	1418680718.34
2050	3228	1200	0.71	9.00	24660029.50	6165007373.92	1787852138.44	7952859512.36	6759930585.50	0.23	1564095491.96
2051	3228	1200	0.73	9.00	25375170.35	6343792587.76	1839699850.45	8183492438.22	6955968572.48	0.22	1532813582.13
2052	3228	1200	0.75	9.00	26111050.29	6527762572.81	1893051146.11	8420813718.92	7157691661.09	0.21	1502157310.48
2053	3228	1200	0.77	9.00	26868270.75	6717067687.42	1947949629.35	8665017316.77	7365264719.26	0.20	1472114164.27
2054	3228	1200	0.79	9.00	27647450.60	6911862650.36	2004440168.60	8916302818.96	7578857396.12	0.19	1442671880.99
2055	3228	1200	0.82	9.00	28449226.67	7112306667.22	2062568933.49	9174875600.71	7798644260.60	0.18	1413818443.37
2056	3228	1200	0.84	9.00	29274254.24	7318563560.57	2122383432.56	9440946993.13	8024804944.16	0.17	1385542074.50
2057	3228	1200	0.86	9.00	30123207.62	7530801903.82	2183932552.11	9714734455.93	8257524287.54	0.16	1357831233.01
2058	3228	1200	0.89	9.00	30996780.64	7749195159.03	2247266596.12	9996461755.15	8496992491.88	0.16	1330674608.35
2059	3228	1200	0.91	9.00	31895687.27	7973921818.65	2312437327.41	10286359146.05	8743405274.14	0.15	1304061116.18
Total								188060876459.57	159851744990.64		46854019378.50

Table B5: Truck Toll Lanes Revenue Calculations

Year	Lane-miles	Weekday Peak Vol ETL	Average Peak Toll	Peak Hours	Peak Revenue Weekday	Annual Revenue Weekday	Annual Non-peak Revenue	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2020	49.40	320.00	0.70	7.00	77459.20	19364800.00	5615792.00	24980592.00	21233503.20	1.00	21233503.20
2021	49.40	390.00	0.72	7.00	97141.10	24285274.65	7042729.65	31328004.30	26628803.65	0.95	25360765.38
2022	49.40	460.00	0.74	7.00	117899.40	29474851.03	8547706.80	38022557.83	32319174.16	0.91	29314443.68
2023	49.40	530.00	0.76	7.00	139780.00	34944998.93	10134049.69	45079048.62	38317191.33	0.86	33099830.54
2024	49.40	600.00	0.78	7.00	162830.51	40707627.06	11805211.85	52512838.90	44635913.07	0.82	36722076.14
2025	98.80	460.00	0.81	7.00	256913.98	64228493.97	18626263.25	82854757.22	70426543.64	0.78	55181039.75
2026	98.80	495.00	0.83	7.00	284479.17	71119792.49	20624739.82	91744532.31	77982852.46	0.75	58192005.18
2027	98.80	530.00	0.86	7.00	313427.08	78356770.16	22723463.35	101080233.51	85918198.48	0.71	61060459.58
2028	98.80	565.00	0.88	7.00	343814.72	85953680.79	24926567.43	110880248.22	94248210.99	0.68	63790899.00
2029	98.80	600.00	0.91	7.00	375701.26	93925314.20	27238341.12	121163655.31	102989107.02	0.64	66387696.66
2030	148.20	507.00	0.93	8.00	560012.78	140003194.84	40600926.50	180604121.34	153513503.14	0.61	94243974.17
2031	148.20	530.00	0.96	8.00	602394.81	150598702.90	43673623.84	194272326.74	165131477.73	0.58	96548955.00
2032	148.20	553.00	0.99	8.00	646764.03	161691007.74	46890392.24	208581399.98	177294189.98	0.56	98724039.01
2033	148.20	577.00	1.02	8.00	694403.52	173600880.82	50344255.44	223945136.26	190353365.82	0.53	100948454.06
2034	148.20	600.00	1.04	8.00	743023.80	185755951.16	53869225.84	239625177.00	203681400.45	0.51	102872947.99
2035	197.60	530.00	1.07	8.00	900495.32	225123829.08	65285910.43	290409739.51	246848278.58	0.48	118738242.63
2036	197.60	548.00	1.11	8.00	958079.44	239519860.81	69460759.63	308980620.44	262633527.37	0.46	120315444.95
2037	197.60	565.00	1.14	8.00	1016447.11	254111777.87	73692415.58	327804193.46	278633564.44	0.44	121566901.22
2038	197.60	583.00	1.17	8.00	1079245.55	269811388.19	78245302.58	348056690.77	295848187.15	0.42	122931032.47
2039	197.60	600.00	1.21	8.00	1142926.59	285731648.49	82862178.06	368593826.55	313304752.57	0.40	123985329.49
2040	247.00	544.00	1.24	8.00	1332880.99	333220248.47	96633872.06	429854120.53	365376002.45	0.38	137706372.62
2041	247.00	558.00	1.28	8.00	1406831.39	351707846.89	101995275.60	453703122.48	385647654.11	0.36	138425280.88
2042	247.00	572.00	1.31	8.00	1483949.95	370987487.78	107586371.46	478573859.24	406787780.36	0.34	139060350.27
2043	247.00	586.00	1.35	8.00	1564358.25	391089561.55	113415972.85	504505534.40	428829704.24	0.33	139614646.78
2044	247.00	600.00	1.39	8.00	1648182.22	412045555.13	119493210.99	531538766.11	451807951.19	0.31	140091147.28
2045	247.00	600.00	1.43	8.00	1695979.50	423994876.22	122958514.10	546953390.33	464910381.78	0.30	137289324.33
2046	247.00	600.00	1.47	8.00	1745162.91	436290727.63	126524311.01	562815038.65	478392782.85	0.28	134543537.84
2047	247.00	600.00	1.51	8.00	1795772.63	448943158.74	130193516.03	579136674.77	492266173.55	0.27	131852667.09
2048	247.00	600.00	1.56	8.00	1847850.04	461962510.34	133969128.00	595931638.34	506541892.59	0.26	129215613.75
2049	247.00	600.00	1.60	8.00	1901437.69	475359423.14	137854232.71	613213655.85	521231607.47	0.24	126631301.47
2050	247.00	600.00	1.65	9.00	2201151.81	550287952.21	159583506.14	709871458.35	603390739.60	0.23	139611009.87
2051	247.00	600.00	1.70	9.00	2264985.21	566246302.83	164211427.82	730457730.64	620889071.05	0.22	136818789.67
2052	247.00	600.00	1.75	9.00	2330669.78	582667445.61	168973559.23	751641004.83	638894854.11	0.21	134082413.88
2053	247.00	600.00	1.80	9.00	2398259.21	599564801.53	173873792.44	773438593.97	657422804.88	0.20	131400765.60
2054	247.00	600.00	1.85	9.00	2467808.72	616952180.77	178916132.42	795868313.20	676488066.22	0.19	128772750.29
2055	247.00	600.00	1.90	9.00	2539375.18	634843794.02	184104700.26	818948494.28	696106220.14	0.18	126197295.28
2056	247.00	600.00	1.96	9.00	2613017.06	653254264.04	189443736.57	842698000.62	716293300.52	0.17	123673349.38
2057	247.00	600.00	2.02	9.00	2688794.55	672198637.70	194937604.93	867136242.63	737065806.24	0.16	121199882.39
2058	247.00	600.00	2.07	9.00	2766769.59	691692398.19	200590795.48	892283193.67	758440714.62	0.16	118775884.74
2059	247.00	600.00	2.13	9.00	2847005.91	711751477.74	206407928.54	918159406.29	780435495.34	0.15	116400367.05
Total								16787247939.46	14269160748.54		4182580790.58

Table B6: Express Lane Cost Components per Year

Express Toll Lanes per Year over 25 Years	Express Toll Lanes Interchanges per Year over 25 Years
2355720000	667800000
2424035880	687166200
2494332921	707094019.8
2566668575	727599746.4
2641101964	748700139
2717693921	770412443.1
2796507045	792754403.9
2877605749	815744281.6
2961056316	839400865.8
3046926949	863743490.9
3135287830	888792052.1
3226211177	914567021.6
3319771301	941089465.3
3416044669	968381059.8
3515109965	996464110.5
3617048154	1025361570
3721942550	1055097055
3829878884	1085694870
3940945372	1117180021
4055232787	1149578242
4172834538	1182916011
4293846740	1217220575
4418368295	1252519972
4546500976	1288843051
4678349504	1326219499
84769022061	24030340164
58893000000 (Total)	16695000000 (Total)

Appendix C: Managed Arterials Details

The managed arterials routings and components are listed in several tables in this appendix. Table C1 details the overall alignment of the managed arterial. Some managed arterials reflect one street name, such as SR 23. Others can have 10 different street names. Multiple alignments are caused by multiple factors including changing street names, missing alignments, differing travel direction and more.

Most managed arterials are a minimum of three lanes in each direction, with some sections consisting of two. Some managed arterials need new lane additions or conversions. One type of conversion is making a travel lane out of a parking lane. Table C2 has a comprehensive list of additions and conversions.

Table C3 includes the complete list of 559 grade separations. Each grade separation and its cost is listed. Where a managed arterial intersects with a typical surface street, the grade separation is estimated to cost $42 million. However, when two managed arterials intersect, both will need grade separations. Constructing two managed grade separations at the same intersection is estimated to cost $78 million.

Several managed arterials need new alignments in certain locations. Often time streets dead end near rivers or other physical landmarks. When necessary and if cost-effective, we suggested new alignments to complete a managed arterial. These are detailed in Table C4.

Tables C2, C3 and C4 list the components by type (widening, grade separation, new alignments, etc.). Table C5 lists each component for each managed arterial in geographical order (grade separation, widening, new alignment, etc). Table C5 includes all components of all Southern California managed arterials.

Table C6 includes the complete revenue and cost calculations for building the managed arterial network. The roadway widenings, tolled grade separations and new alignments are listed separately and combined. Revenue and costs were calculated in a similar method to the express lane network. Those calculations are detailed in Appendix B.

Table C1: Managed Arterials, Overall Alignments

No.	Suggested Alignment	Dir.	From	To	Relieves Traffic
1.	Overall	E-W	Valley Circle Blvd	Foothill Blvd	SR 118, US 101, SR 134
	Roscoe Blvd		Valley Circle Blvd	Lankershim Blvd	
	Tuxford St		Lankershim Blvd	Tuxford St NE	
	La Tuna Canyon Rd		Tuxford St NE	Tujunga Canyon Blvd	
	Tujunga Canyon Blvd		La Tuna Canyon Blvd	Foothill Blvd	
2.	Overall	E-W	SR 1	I-605	I-10, I-210, US 101
	San Vicente Blvd		SR 1	Wilshire Blvd	
	Wilshire Blvd		San Vicente Blvd	Santa Monica Blvd	
	Santa Monica Blvd		Wilshire Blvd	Sunset Blvd	
	Sunset Blvd		Santa Monica Blvd	SR 110	
	SR 110		Sunset Blvd	Grevelia St	
	Grevelia St		SR 110	Garfield Ave	
	Garfield Ave		Grevelia St	E. Main St	
	E Main St.		Garfield Ave.	Vega St	
	Las Tunas Dr		Vega St	Live Oak Ave	
	Live Oak Ave		Las Tunas	I-605	
3.	Overall	E-W	SR 1	Mission Blvd	I-10, I-105, SR 60, SR 91,
	SR 90		SR 1	Slauson Ave.	
	Slauson Ave		SR 90	Telegraph Rd	
	Telegraph Rd,		Slauson Ave	Imperial Highway	
	Imperial Highway,		Telegraph Rd	Valencia Ave	
	Valencia Ave,		Imperial Highway	Carbon Canyon Rd	
	Carbon Canyon Rd,		Valencia Ave	Chino Hills Parkway	
	Chino Hills Parkway,		Carbon Canyon Rd	New Alignment	
	New Alignment,		Chino Hills Parkway	Merrill Ave	
	Merrill Ave,		New Alignment	Archibald Ave	
	Archibald Ave,		Merrill Ave	Limonite Ave	
	Limonite Ave/Riverview Dr		Archibald Ave	Mission Blvd	
	New Alignment		Mission Blvd	SR 60	
4.	Overall	E-W	Catalina Ave	SR 241	I-405, SR 22, SR 91
	Torrance Blvd Euclid Rd		Catalina Ave	Palos Verde Blvd	
	Palos Verdes Blvd		Torrance Blvd	Carson St	
	Carson St		Palos Verde Blvd	Santa Fe Ave	
	New Alignment		Santa Fe Ave	Intersection of Carson St/Long Beach Blvd	
	Carson St/Lincoln Ave		Intersection of Carson St/Long Beach Blvd	Euclid Rd	
	Euclid Rd		Carson St/Lincoln Ave	Ball Rd/Taft Ave	
	Ball Rd/Taft Ave		Euclid Rd	Cannon St	
	Cannon St		Ball Rd/Taft Ave	Santiago Canyon Rd	
	Santiago Canyon Rd		Cannon St	Santiago Canyon Rd S. of Lolita St	
	New Alignment		Santiago Canyon Rd S. of Lolita St.	SR 241	
5.	Overall	E-W	SR 1	Eastern Transportation Corridor	I-5, I-405, SR 241, SR 261
	Warner Ave, Tustin		SR 1	Euclid St	
	Euclid St		Warner Ave	Edinger Ave	
	Edinger Ave		Euclid St	Tustin Ranch Rd	
	Tustin Ranch Rd		Euclid St	Portola Parkway	
	Portola Parkway		Tustin Ranch Rd	SR 241	
6.	Overall	E-W	SR 1	Plano Trabuco Rd	I-5, SR 133
	Crown Valley Parkway		SR 1	Alicia Parkway	
	Alicia Parkway		Crown Valley Parkway	Santa Margarita Parkway	
	Santa Margarita Parkway		Alicia Parkway	Plano Trabuco Rd	

Table C1: Managed Arterials, Overall Alignments

No.	Suggested Alignment	Dir.	From	To	Relieves Traffic
7.	SR 74	E-W	I-5	San Jacinto Rd	SR 60, SR 91
8.	Overall	N-S	SR 1	SR 118	SR 23
	SR 23		SR 1	US 101	
	West Lake Blvd		US 101	West Lake Blvd west of Oak Valley Lane	
	New Alignment		West Lake Blvd west of Oak Valley Lane	Wood Ranch Parkway at Long Canyon Rd	
	Wood Ranch Parkway		Wood Ranch Parkway at Long Canyon Rd	Madera Rd	
	Madera Rd		Wood Ranch Parkway	SR 118	
9.	Overall	N-S	SR 107	SR 118	I-110, I-405, SR 23
	SR 1		SR 107	SR 27	
	SR 27		SR 1	SR 118	
10.	Overall	N-S	I-405	I-210	I-5, I-110, I-210 I-405, US 101, SR 170, SR 170
	La Cienega Blvd		I-405	Sunset Blvd	
	Sunset Blvd		La Cienega Blvd	Laurel Canyon Blvd	
	Laurel Canyon Blvd		Sunset Blvd	Sheldon St	
	Sheldon St		Laurel Canyon Blvd	Wentworth St	
	Wentworth St		Sheldon St	McBroom St	
	McBroom St Extension		Wentworth St	I-210	
11.	Overall	N-S	SR 103	SR 134	I-110, I-710, SR 2
	SR 47		SR 103	Alameda St	
	Alameda St		SR 47 South	Spring St	
	Spring St		Alameda St	Broadway	
	Broadway		Spring St	Daly St	
	Daly St		Broadway	Pasadena Ave	
	Pasadena Ave		Daly St	Figueroa St	
	Figueroa St		Pasadena Ave	SR 134	
12.	Overall	N-S	Livingston Dr.	East Sierra Madre Blvd	I-605, I-710, SR 110
	Ximeno Ave		Livingston Dr	Traffic Circle	
	Lakewood Blvd		Traffic Circle	Telegraph Rd	
	Rosemead Blvd		Telegraph Rd	Sierra Madre Villa Ave	
	Sierra Madre Villa Ave		Rosemead Blvd	East Sierra Madre Blvd	
13.	Overall	N-S	W 25th St.	I-210	I-5, I-110, I-210, I-405, US 101
	Western Ave		W 25th St.	Western Ave at Los Feliz Blvd	
	New Alignment		Western Ave at Los Feliz Blvd	Buena Vista St at SR 134	
	Buena Vista St		SR 134	Glen Oaks Blvd	
	Glen Oaks Blvd		Buena Vista St	I-210	
14.	Overall	N-S	SR 1	Sierra Madre Ave	SR 57, I-405, I-605
	Beach Blvd		SR 1	Gregory Lane	
	New Alignment		Gregory Lane	Whittier Blvd	
	Hacienda Rd		Whittier Blvd	Colima Rd	
	Colima Rd		Hacienda Rd	Azusa Ave	
	Azusa Ave		Colima Rd	Sierra Madre Ave	
15.	Overall	N-S	SR 91	Base Line Rd	SR 57, SR 71
	Fairmont Blvd		SR 91	Fairmont Blvd E of Quarter House Rd	
	New Alignment		Fairmont Blvd E of Quarter House Rd	Carbon Canyon Rd E of Beryl St	
	Carbon Canyon Rd		Carbon Canyon Rd E of Beryl St	Chino Hills Parkway	

Table C1: Managed Arterials, Overall Alignments

No.	Suggested Alignment	Dir.	From	To	Relieves Traffic
	Chino Hills Parkway		Carbon Canyon Rd	Peyton Dr	
	Peyton Dr		Chino Hills Parkway	Garey Ave	
	Riverside Dr		Garey Ave	Towne Ave	
	Towne Ave		Riverside Dr.	Base Line Rd	
16.	Euclid Ave	N-S	SR 71	W 24th St	I-15, SR 57, SR 71
17.	Overall	N-S	SR 74 ½ mi. E of I-15	SR 210	I-15, I-215
	El Toro Cut Off Rd		SR 74 ½ mi. E of I-15	El Toro Rd at El Toro Rd Cutoff	
	El Toro Rd		El Toro Rd at El Toro Cutoff	El Mineral Rd	
	Piedras Rd		El Mineral Rd	Santa Rosa Mine Rd	
	Santa Rosa Mine Rd		Piedras Rd	Lake Matthews Dr	
	Gavilan Rd		Lake Matthews Dr	Cajalco Rd	
	Cajalco Rd		Gavilan Rd	El Sobrante Rd	
	El Sobrante Rd		Cajalco Rd	Mockingbird Canyon Rd	
	Mockingbird Canyon Rd		El Sobrante Rd	Van Buren Blvd	
	Van Buren Blvd		Mockingbird Canyon Rd	Jurupa Rd	
	Jurupa Rd		Van Buren Blvd	Sierra Ave	
	Sierra Ave		Jurupa Rd	I-15	
18.	Overall	N-S	I-15	I-10	I-15, I-215
	SR 79		I-15	SR 74	
	New Alignment		SR 74	Juniper Springs Curve from E/W to N/S	
	Juniper Springs Rd		Juniper Springs Curve from E/W to N/S/	Juniper Flats Rd	
	Juniper Flats Rd		Juniper Springs Rd	Contour Ave	
	Contour Ave		Juniper Flats Rd	Hansen Ave	
	Hansen Ave		Contour Ave	Ramona Expressway	
	Davis Rd		Ramona Expressway	South of Alessandro Blvd	
	Theodore St		South of Alessandro Blvd	Ironwood Ave	
	Ironwood Ave		Theodore St	Highland Blvd	
	Highland Blvd		Ironwood Ave	Redlands Blvd	
	Redlands Blvd		Highland Blvd	San Timoteo Canyon Rd	
	San Timoteo Canyon Rd		Redlands Blvd	Alessandro Rd	
	Alessandro Rd		San Timoteo Canyon Rd	Crescent Ave	
	Crescent Ave		Alessandro Rd	San Jacinto St	
	San Jacinto St		Crescent St	Highland St	
	Highland St		San Jacinto St	San Mateo St	
	San Mateo St.		Highland St.	Tennessee St	
	Tennessee St		San Mateo St	I-10	

Table C2: Arterial Additions and Conversions

Road	From	To	Scope	Cost
Roscoe Blvd	Valley Circle Blvd	SR 27	Convert parking lanes to travel lanes (2.3 miles, 4.6 lane miles)	$26.7M
Roscoe Blvd	Haskell Ave	Landon Ave	Add 1 lane in each direction (0.4 miles, 0.8 lane miles)	$10.2M
Tuxford St	SR 170	Sunland Canyon Blvd	Convert parking lanes to travel lanes (2.8 miles, 5.6 lane miles)	$32.5M
La Tuna Canyon Rd	Sunland Canyon Blvd	Elbon St	Add 1 lane in each direction, Convert parking lanes to travel lanes (1.8 miles, 7.2 lane miles)	$66.7M
La Tuna Canyon Rd	Elbon St	I-210	Convert parking lane to travel lanes (2.5 miles, 5.0 lane miles)	$29M
Tujunga Canyon Rd	La Tuna Canyon Rd	Foothill Blvd	Add 1 lane in each direction (1.0 mile, 2.0 lane miles)	$25.4M
San Vicente Blvd	26th St	Wilshire Blvd	Add 1 lane in each direction (2.0 miles, 4.0 lane miles)	$50.8M
Santa Monica Blvd	Wilshire Blvd	Doheny Dr	Add 1 lane in each direction (1.5 miles, 3.0 lane miles)	$17.4M
Santa Monica Blvd	Doheny Dr	Sunset Blvd	Add 1 lane total, convert parking lane to travel lane (6.5 miles, 13.0 lane miles)	$120.2M

Table C2: Arterial Additions and Conversions				
Road	**From**	**To**	**Scope**	**Cost**
Sunset Blvd	Santa Monica Blvd	SR 110	Convert parking lanes to travel lanes (3.0 miles, 6.0 lane miles)	$34.8M
Grevalia St	SR 110	Stratford Ave	Add 2 lanes in each direction (0.3 miles, 1.2 lane miles)	$15.2M
Garfield Ave	Stratford Ave	Huntington Dr	Add 2 lanes in each direction (1.1 miles, 4.4 lane miles)	$55.9M
Garfield Ave	Huntington Dr	Main St	Add 1 lane in each direction (0.9 mile, 1.8 lane miles)	$22.9M
Main St/Las Tunas Dr	Garfield Ave	San Gabriel Blvd	Convert parking lanes to travel lanes (2.2 miles, 4.4 lane miles)	$25.5M
Las Tunas Dr	Rosemead Blvd	Longden Ave	Convert parking lanes to travel lanes (4.4 miles, 8.8 lane miles)	$51M
Slauson Ave	Alviso St	Ruthelen St	Add 1 lane total, convert parking lanes to travel lanes (1.8 miles, 3.6 lane miles)	$33.3M
Slauson Ave	Ruthelen St	Santa Fe Ave	Add 1 lane in each direction (4.7 miles, 9.4 lane miles)	$119.4M
Slauson Ave	Santa Fe Ave	Alamo Ave	Convert parking lanes to travel lanes (3.2 miles, 6.4 lane miles)	$37.1M
Slauson Ave	Alamo Ave	I-710	Add 1 lane in each direction (0.3 miles, 0.6 lane miles)	$7.6M
Slauson Ave	Garfield Ave	Greenwood Ave	Convert parking lanes to travel lanes (0.7 miles, 1.4 lane miles)	$8.1M
Telegraph Rd	Slauson Ave	Tweedy Ln	Add 1 lane in each direction (0.5 mile, 1.0 lane mile)	$12.7M
Telegraph Rd	True Ave	I-605	Add 1 lane in each direction (0.3 mile, 0.6 lane mile)	$7.6M
Valencia Ave	SR 90	Carbon Canyon Rd	Add 1 lane in each direction (1.0 mile, 2.0 lane miles)	$25.4M
Carbon Canyon Rd	Valencia Ave	Olinda Dr	Add 1 lane in each direction (2.8 miles, 5.6 lane miles)	$63.5M
Carbon Canyon Rd	Olinda Dr	Chino Hills Parkway	Add 2 lanes in each direction (5.6 miles, 22.4 lane miles)	$284.4M
Chino Hills Parkway	Carbon Canyon Rd	Central Ave	Add 1 lane in each direction (3.0 miles, 6.0 lane miles)	$76.2M
Merrill Ave	Central Ave	Cypress Ave. North	Add 2 lanes in each direction (0.9 miles, 3.6 lane miles)	$49.5M
Cypress Ave/Merrill Ave	Cypress Ave North	Archibald Ave	Add 2 lanes in each direction (5.9 miles, 23.6 lane miles)	$299.7M
Archibald Ave	Merrill Ave	Limonite St	Add 2 lanes in each direction (0.5 miles, 2.0 lane miles)	$25.4M
Limonite St	Archibald Ave	Wineville Ave	Add 1 lane in each direction (3.0 miles, 6.0 lane miles)	$76.2M
Limonite St	Wineville Ave	Homestead St	Add 2 lanes in each direction (2.7 miles, 10.8 lane miles)	$137.2M
Limonite St	Homestead St	Mission Blvd	Add 1 lane in each direction (5.2 miles, 10.4 lane miles)	$132.1M
Riverview Dr	Mission Blvd	SR 60	Add 2 lanes in each direction (0.4 mile, 1.6 lane miles)	$20.3M
Torrance Blvd	Catalina Ave		Add 1 lane in each direction (1.5 miles, 3.0 lane miles)	$38.1M
Carson St	Hawthorne Blvd	Del Amo Circle Blvd	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$17.8M
Carson St	Madrona Ave	Via Oro Ave	Convert parking lanes to travel lanes (7.6 miles, 15.2 lane miles)	$88.2M
Bixby Rd	Country Club Rd	Atlantic Ave	Add 1 additional lane in each direction, Convert parking lane to travel lane in each direction (0.8 miles, 1.6 lane miles))	$29.6M
Atlantic Ave	Bixby Rd	Carson St	Add 1 lane in each direction (0.4 miles, 0.8 lane-miles)	$10.2M
Carson St	Atlantic Ave	Orange Ave	Convert parking lane to travel lane in each direction (1.0 converted-miles)	$5.8M
Carson St	Orange Ave	Cherry Ave	Add 1 lane in each direction (1.0 lane-miles)	$12.7M
Carson St	Los Coyotes Diagonal	LB Towne Center Dr	Add 1 lane in each direction (1.0 lane-miles)	$12.7M
Carson St /Lincoln Ave	Pioneer Blvd	Euclid St	Add 1 lane in each direction (16.2 lane miles)	$205.7M
Euclid St	Broadway	Ball Rd/Taft Ave	Add 1 lane in each direction (1.4 lane miles)	$17.8M
Ball Rd	Euclid St	Hampstead St	Add 1 lane in each direction (0.5 mile—1.0 lane miles)	$12.7M
Ball Rd	State College Blvd	Sunkist Rd	Convert parking lane to travel lane in each direction (1.0 converted-miles)	$5.8M
Taft Ave	SR 57	Tustin St	Add 1 lane in each direction (4.8 lane miles)	$61M
Taft Ave	Santiago Blvd	Center Dr	Convert parking lane to travel lane in each direction Add 1 additional lane in each direction (2.4 lane-miles)	$22.2M
Taft Ave	Center Dr	Cannon St	Add 2 lanes in each direction (4.0 lane miles)	$50.8M
Cannon St	Taft Ave	Santiago Canyon St	Add 1 lane in each direction (0.8 lane miles)	$10.2M
E Santiago Canyon	Cannon St	Jamboree Rd	Add 1 lane in each direction (5.8 lane miles)	$73.7M
Jamboree Rd	E Santiago Canyon Rd	E Santiago Canyon Rd	Add 1 lane in each direction (0.4 lane miles)	$5.1M
E Santiago Canyon Rd	Chapman Ave	SR 241/SR 261	Add 1 lane in each direction (2 lane miles)	$25.4M
Warner Ave	SR 1	Algonquin St	Add 1 lane each direction (0.9 miles, 1.8 lane miles)	$22.9M
Warner Ave	Raitt St	Bristol St	Convert westbound parking lane to travel lane (0.6 converted miles)	$3.5M
Warner Ave	Bristol St	Grand Ave	Add one lane each direction (8.0 lane miles)	$101.6M
Warner Ave	Grand Ave	Wright St	Add one lane to westbound through lane (0.4 lane miles)	$5.1M
Portola Parkway	Jefferey Rd	SR 241	Add 1 lane in each direction (6.8 lane miles)	$86.4M
Crown Valley Parkway	SR 1	Sea Island Dr	Add 1 lane in each direction (0.8 lane mile)	$10.2M
Crown Valley Parkway	Sea Island Dr	Camino Del Avion	Add 1 lane in each direction (0.4 lane miles)	$5.1M

Table C2: Arterial Additions and Conversions

Road	From	To	Scope	Cost
SR 74	Camino Capistrano	Hunt Club Dr	Add 1 lane in each direction (3.0 lane miles)	$38.1M
SR 74	Hunt Club Dr	Reata Rd	Add 2 lanes in each direction (3.6 lane miles)	$45.7M
SR 74	Reata Rd	Le Harve St	Add 1 lanes in each direction (54.6 lane miles)	$693.4M
SR 74	Le Harve St	Hunco Way	Add 2 lanes in each direction (12.0 lane miles)	$152.4M
SR 74	Hunco Way	I-15	Add 1 lane in each direction (1.0 lane miles)	$12.7M
SR 74	Dexter Ave	I-215	Add 1 lane in each direction (20.6 lane miles)	$261.6M
SR 74	Case Rd	¼ mile E of San Jacinto Rd	Add 1 lane in each direction (33.8 lane miles)	$429.3M
SR 1	Ocean Ave	Herondo St	Add 2 lanes in each direction (9 lane miles)	$114.3M
SR 1	Jefferson Blvd	Fiji Way	Add one southbound lane (0.5 lane mile)	$6.4M
SR 1	Washington Blvd	I-10	Add 1 lane each direction (5.6 lane miles)	$71.1M
SR 1/SR 27	Temescal Canyon Rd	Avenue St. Louis	Add one lane in each direction (29.4 lane miles)	$373.4M
SR 27	Parthenia St	Prarie St	Convert Parking Lanes to Travel Lanes (1.6 lane miles)	$20.3M
SR 27	Marilla St	SR 118	Convert parking lanes to travel lanes (4.2 lane miles)	$53.3M
SR 23	SR 1	Triunfo Canyon Rd	Add 2 lanes in each direction (22 lane miles)	$279.4M
Westlake Blvd	Hillcrest Dr	Eagle Claw Ave	Add one lane in each direction (7.2 lane miles)	$91.4M
Westlake Blvd	Eagle Claw Ave	Oak Valley Lane	Add 2 lanes in each direction (1.2 lane mile)	$15.2M
Wood Ranch Parkway	Long Canyon Rd	Madera Rd	Add 1 lane in each direction (4 lane miles)	$50.8M
Madera Rd	Wood Ranch Parkway	MaCaw Lane	Convert (south-westbound parking lane to travel lane (1.1 converted lane miles)	$5.3M
La Cienega Blvd	I-405	Glenway Dr	Convert southbound parking lane to travel lane (0.7 miles, 0.7 lane miles)	$3.4M
La Cienega Blvd	Beverly Blvd	Santa Monica Blvd	Convert parking lanes to travel lanes (0.4 lane miles)	$1.9M
Sunset Blvd	La Cienega Blvd	Marmont Lane	Add 1 lane in each direction (0.5 mile, 1 lane mile)	$12.7M
Laurel Canyon Blvd	Sunset Blvd	Mt. Olympus Dr	Add 1 lane in each direction (0.8 lane miles)	$10.2M
Laurel Canyon Blvd	Mt. Olympus Dr	Mulholland Dr	Add 2 lanes in each direction (7.2 lane miles)	$91.4M
Laurel Canyon Blvd	Mullholland Dr	Maxwellton Rd	Add 1 lane in each direction (3.8 lane miles)	$48.3M
Laurel Canyon Blvd	Maxwellton Rd	Webb Ave	Convert parking lanes to travel lanes (15.4 lane miles)	$73.9M
Laurel Canyon Blvd	Webb Ave	Sheldon St	Add 1 lane in each direction (0.6 mile, 1.2 lane miles)	$15.2M
SR 47	Anaheim St	Alameda St	Convert parking lanes to travel lanes (0.4 mile, 0.8 lane miles)	$3.8M
Alameda St	Alameda St	SR 1	Convert northbound parking lane to travel lane (0.3 mile, 0.3 lane mile)	$1.4M
Alameda St	Sepulveda Blvd	223rd St	Add 1 lane in each direction (1.2 miles, 2.4 lane miles)	$30.5M
Alameda St	I-405	SR 91	Convert parking lanes to travel lanes (3.2 miles, 6.4 lane miles)	$30.7M
Alameda St	SR 91	Nadeau St	Add 1 travel lane in each direction (6.6 miles, 13.2 lane miles)	$167.6M
Alameda St	Nadeau St	E 76th St	Add 1 travel lane northbound, convert parking lane southbound (0.3 miles, 0.6 lane miles)	$7.6M
Alameda St	E 76th St	US 101	Add 1 lane in each direction (5.7 miles, 11.4 lane miles)	$144.8M
Alameda St	Main St	Elmyra St	Add 1 lane in northbound direction (0.5 miles, 0.5 lane miles)	$6.4M
Spring St	Elmyra St	Mesnagers St	Add 1 lane in each direction (0.3 miles, 0.6 lane miles)	$7.6M
Spring St	Mesnagers St	18th Ave	Add 2 lanes in each direction (0.4 miles, 1.6 lane miles)	$20.3M
Daly St	Broadway	Pasadena Ave	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$5.1M
Pasadena Ave	Daly St	French Ave	Add 2 lanes in each direction (0.8 miles, 3.2 lane miles)	$40.6M
Pasadena Ave	French Ave	Figueroa St	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$8.9M
Figueroa St	Pasadena Ave	York Blvd	Convert parking lanes to travel lanes (2.4 miles, 4.8 lane miles)	$27.8M
Figueroa St	York Blvd	Colorado Blvd	Add 1 lane in each direction (1.7 miles, 3.4 lane miles)	$43.2M
Figueroa St	Colorado Blvd	Ramp to SR 134E	Add 2 lanes in each direction (0.1 miles, 0.4 lane miles)	$5.1M
Figueroa St	Ramp to SR 134E	SR 134 Interchange	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$5.1M
Sheldon St	Laurel Canyon Rd	San Fernando Blvd	Add 1 lane in each direction (1.6 lane miles)	$20.3M
San Fernando Blvd	Sheldon St	La Rue St	Add 1 lane in each direction (7.2 lane miles)	$91.4M
San Fernando Blvd and Truman St	La Rue St	Bleeker St	Convert two-way streets to two one way streets (1.4 miles, 11.2 lane miles)	$32.5M
San Fernando Blvd	Bleeker St	I-5	Add 1 lane in each direction (5.4 lane miles)	$68.6M
Ximeno Ave	Livingston St	Anaheim St	Add 1 new lane in each direction, convert parking lanes to travel lanes (1.4 miles, 5.6 lane miles)	$51.8M
Ximeno Ave	Anaheim St	15th St	Add 1 northbound lane, convert parking lanes to travel lanes (0.2 miles, 0.4 converted miles, 0.2 lane miles	$4.9M
Ximeno Ave	15th St	Las Coyotes Diagonal	Convert parking lanes to travel lanes (0.5 miles, 1.0 lane mile)	$5.8M
Rosada St	Las Coyotes Diagonal	Lakewood Blvd	Add 2 new lanes in each direction (0.2 miles, 0.8 lane miles)	$10.2M
Lakewood Blvd	Traffic Circle	E. Stearns St	Convert northbound parking lane to travel lane (0.3 miles, 0.3 lane miles)	$1.7M
Lakewood Blvd	Carson St	Del Amo Blvd	Add 1 new lane in each direction (1.6 miles, 3.2 lane miles)	$40.6M

Table C2: Arterial Additions and Conversions

Road	From	To	Scope	Cost
Lakewood Blvd	Park St	I-105	Convert parking lanes to travel lanes (3.8 miles, 7.6 lane miles)	$44.1M
Lakewood Blvd	Florence Ave	I-5	Convert parking lanes to travel lanes (1.0 miles, 2.0 lane miles)	$11.6M
Rosemead Blvd	E Telegraph Rd	Gallatin Rd	Convert parking lanes to travel lanes (4.3 miles, 8.6 lane miles)	$49.9M
Rosemead Blvd	Gallatin Rd	SR 60	Add 1 lane in each direction (4.5 miles, 9.0 lane miles)	$114.3M
Rosemead Blvd	Marshall Ave	Sierra Madre Villa Ave	Convert parking lanes to travel lanes (5.9 miles, 11.8 lane miles)	$68.4M
Sierra Madre Villa Ave	Rosemead Blvd	E Sierra Madre Blvd	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$5.1M
Western Ave	Paseo Del Mar	25th St	Add 1 lane in each direction (0.5 mile, 1.0 lane mile)	$12.7M
Western Ave	25th St	9th St	Convert northbound parking lane to travel lane and add 1 lane in southbound direction (1.1 new lanes, 1.1 converted lanes, 2.2 lane miles)	$20.4M
Western Ave	9th St	Carson St	Convert parking lanes to travel lanes (6.9 miles, 13.8 lane miles)	$80M
Western Ave	Carson St	Del Amo St	Convert northbound parking lane to travel lane (1.1 miles, 1.1 lane miles)	$6.4M
Western Ave	I-405	Franklin Ave	Convert parking lanes to travel lanes (17.0 miles, 34.0 lane miles)	$197.2M
Buena Vista St	SR 134	San Fernando Valley	Convert parking lanes to travel lanes (6.7 miles, 13.4 lane miles)	$77.7M
Buena Vista St	San Fernando Blvd	Glen Oaks Blvd	Add 1 lane in each direction (0.5 miles, 1.0 lane mile)	$12.7M
Glen Oaks Blvd	Buena Vista St	I-210	Convert parking lanes to travel lanes (10.9 miles, 21.8 lane miles)	$126.4M
Hacienda Rd	Whittier Blvd	Sansinena Lane	Add 1 lane in each direction (0.4 miles, 0.8 lane miles)	$10.2M
Hacienda Rd	Sansinena Lane	Glenmark Dr	Add 2 lanes in each direction (2.6 miles, 10.4 lane miles)	$132.1M
Hacienda Rd	Glenmark Dr	Colima Rd	Add 1 lane in each direction (0.4 miles, 0.8 lane miles)	$10.2M
Colima Rd	Hacienda Rd	Azusa Ave	Add 1 lane in each direction (2.6 miles, 5.2 lane miles)	$66M
Azusa Ave	W Francisquito Ave	E Garvey Ave	Convert southbound parking lane into travel lane (1.4 miles, 1.4 lane miles)	$8.1M
Azusa Ave	Workman Ave	1st Street	Convert parking lanes into travel lanes (3.2 miles, 6.4 lane miles)	$37.1M
Fairmont Blvd	Village Center Dr	Singingwood Dr	Add 1 lane in each direction (5.5 miles, 11.0 lane miles)	$139.7M
Fairmont Blvd	Singingwood Dr	San Antonio Rd	Add 2 lanes in each direction (0.9 miles, 3.6 lane miles)	$45.7M
Peyton Dr	Chino Hills Parkway	Morningfield Dr	Add 1 lane in each direction, convert parking lanes to travel lanes (0.2 miles, 0.8 lane miles)	$10.2M
Peyton Dr	Morningfield Dr	Eucalyptus Ave	Add 2 lanes in each direction (0.3 miles, 1.2 lane miles)	$15.2M
Riverside Dr	SR 71	Towne Ave	Add 1 lane in each direction (0.2 miles, 0.4 lane miles)	$5.1M
Towne Ave	Riverside Dr	Baseline Rd	Convert parking lanes to travel lanes (7.2 miles, 14.4 lane miles)	$83.5M
Euclid Ave	SR 71	Pomono Rincon Rd	Add 1 lane in each direction (0.5 miles, 1.0 lane miles)	$12.7M
Euclid Ave	Pomono Rincon Rd	Johnson Ave	Add 2 lanes in each direction (0.5 miles, 2.0 lane miles)	$25.4M
Euclid Ave	Johnson Ave	Merion St	Add 1 lane in each direction (2.0 miles, 4.0 lane miles)	$50.8M
Euclid Ave	Merion St	H Street	Convert parking lanes to travel lanes (3.5 miles, 7.0 lane miles)	$40.6M
Euclid Ave	Foothill Blvd	24th St	Add 1 lane in each direction (3.0 miles, 6.0 lane miles)	$76.2M
El Toro Cutoff Rd	SR 74	El Toro Rd	Add 2 lanes in each direction (1.3 miles, 5.2 lane miles)	$66M
El Toro Rd	El Toro Cutoff Rd	Fort Lander Lane	Add 2 lanes in each direction (8.8 miles, 35.2 lane miles)	$223.5M
El Toro Rd	Fort Lander Rd	El Mineral Rd	Add 2 lanes in each direction (0.5 miles, 2.0 lane miles)	$25.4M
Piedras Rd	El Mineral Rd	Santa Rosa Mine Rd	Add 2 lanes in each direction (0.9 miles, 3.6 lane miles)	$45.7M
Santa Rosa Mine Rd	Piedras	Lake Matthews Dr	Add 2 lanes in each direction (1.0 mile, 4.0 lane miles)	$50.8M
Gavilian Rd	Lake Matthews Dr	Cajalco Rd	Add 2 lanes in each direction (2.9 miles, 11.6 lane miles)	$147.3M
Cajalco Rd	Gavilian Rd	El Sobrante Rd	Add 2 lanes in each direction (0.3 miles, 1.2 lane miles)	$15.2M
El Sobrante Rd	Cajalco Rd	Mockingbird Canyon Rd	Add 2 lanes in each direction (1.1 miles, 4.4 lane miles)	$55.9M
Mockingbird Canyon Rd	El Sobrante Rd	Van Buren Blvd	Add 2 lanes in each direction (3.5 miles, 14.0 lane miles)	$177.8M
Van Buren Blvd	Mockingbird Canyon Rd	Rudcill St	Add 1 lane in each direction (2.6 miles, 5.2 lane miles)	$66M
Van Buren Blvd	Garfield St	Cypress Ave	Add 1 lane in each direction (1.8 miles, 3.6 lane miles)	$45.7M
Van Buren Rd	Jurupa Ave	Jurupa Rd	Add 1 lane in each direction (3.1 miles, 6.2 lane miles)	$78.7M
Jurupa Rd	Van Buren Rd	Valley Way	Add 2 lanes in each direction (2.7 miles, 10.8 lane miles)	$137.2M
Valley Way	Jurupa Rd	Mission Blvd	Add 2 lanes in each direction (0.4 miles, 1.2 lane miles)	$15.2M
Armstrong Rd	Mission Blvd	Sierra Ave	Add 1 lane in each direction (1.0 mile, 2.0 lane miles)	$25.4M
Sierra Ave	Armstrong Rd	Santa Ana Ave	Add 1 lane in each direction (2.6 miles, 5.2 lane miles)	$66M
Sierra Ave	San Bernardino Rd	Miller Ave	Convert parking lanes to travel lanes (1.5 miles, 3.0 lane miles)	$17.4M
Sierra Ave	Miller Ave	Baseline Rd	Add 1 lane in each direction (3.0 miles, 6.0 lane miles)	$76.2M
Sierra Ave	Summit Ave	I-15	Add 2 lanes in each direction (2.0 miles, 8.0 lane miles)	$101.6M
SR 79	Hunter Rd	Pourroy Rd	Add 1 lane in each direction (3.9 miles, 7.8 lane miles)	$99.1M
SR 79	Pourroy Rd	SR 74	Add 2 lanes in each direction (9.3 miles, 37.2 lane miles)	$472.4M
Juniper Springs Rd	Juniper Springs Curve	Juniper Flat Rd	Add 2 lanes in each direction (3.5 miles, 14.0 lane miles)	$177.8M
Juniper Flats Rd	Juniper Springs Rd	Contour Ave	Add 2 lanes in each direction (2.8 miles, 11.2 lane miles)	$142.2M
Contour Ave	Juniper Flats Rd	Hansen Ave	Add 2 lanes in each direction (1.1 miles, 4.4 lane miles)	$55.9M
Hansen Ave	Contour Ave	Ramona Expressway	Add 2 lanes in each direction (2.1 miles, 8.4 lane miles)	$106.7M

Table C2: Arterial Additions and Conversions

Road	From	To	Scope	Cost
Davis Rd	Ramona Expressway	Alessandro Blvd	Add 2 lanes in each direction (5.9 miles, 23.6 lane miles)	$299.7M
Theodore St	Alessandro Blvd	Ironwood Ave	Add 2 lanes in each direction (2.0 miles, 8.0 lane miles)	$101.6M
Ironwood Ave	Theodore St	Redlands Blvd	Add 2 lanes in each direction (1.0 mile, 4.0 lane miles)	$50.8M
Redlands Blvd	Ironwood Ave	San Timoteo Canyon Rd	Add 2 lanes in each direction (3.3 miles, 13.2 lane miles)	$167.6M
San Timoteo Canyon Rd	Redlands Blvd	Alessandro Rd	Add 2 lanes in each direction (2.2 miles, 8.8 lane miles)	$111.8M
Alessandro Rd	San Timoteo Canyon Rd	Crescent Ave	Add 2 lanes in each direction (1.6 miles, 6.4 lane miles)	$81.3M
Crescent Ave	Alessandro Rd	San Jacinto St	Add 2 lanes in each direction (.01 miles, .04 lane miles)	$0.5M
San Jacinto St	Crescent Ave	Highland Ave	Add 2 lanes in each direction (0.2 miles, 0.8 lane miles)	$10.2M
Highland Ave	San Jacinto St	San Mateo St	Add 2 lanes in each direction (0.2 miles, 0.8 lane miles)	$10.2M
San Mateo St	Highland Ave	Clifton Ave	Add 1 lane in each direction, convert parking lanes to travel lanes (0.4 miles, 1.6 lane miles)	$14.8M
San Mateo St	Clifton Ave	I-10/I-210	Convert parking lanes to travel lanes (2.1 miles, 4.2 lane miles)	$24.4M

Table C3: Managed Arterial Grade Separated Interchanges

Grade Separation	Cost	Grade Separation	Cost
Roscoe Blvd at Fallbrook Ave	$42M	San Fernando Blvd at Branford St	$42M
Roscoe Blvd at SR 27 (Dual)	$78M	San Fernando Blvd at Osborne St	$42M
Roscoe Blvd at Canoga Ave	$42M	San Fernando Blvd at Van Nuys Blvd	$42M
Roscoe Blvd at De Soto Ave	$42M	San Fernando Blvd at Paxton St	$42M
Roscoe Blvd at Mason Ave	$42M	San Fernando Blvd/Truman St at Hubbard St	$42M
Roscoe Blvd at Winnetka Ave	$42M	San Fernando Blvd at Polk St	$42M
Roscoe Blvd at Corbin Ave	$42M	San Fernando Blvd at Roxford St	$42M
Roscoe Blvd at Tampa Ave	$42M	Alameda St at Anaheim St	$42M
Roscoe Blvd at Wilbur Ave	$42M	Alameda St at Santa Fe Ave.	$42M
Roscoe Blvd at Reseda Blvd	$42M	Alameda Ave at Greenleaf Blvd	$42M
Roscoe Blvd at Lindley Ave	$42M	Alameda Ave at Alondra Blvd	$42M
Roscoe Blvd at Balboa Blvd	$42M	Alameda Ave at Compton Blvd	$42M
Roscoe Blvd at Woodley Ave	$42M	Alameda Ave at El Segundo Blvd	$42M
Roscoe Blvd at Sepulveda Blvd	$42M	Alameda Ave at Imperial Highway	$42M
Roscoe Blvd at Van Nuys Blvd	$42M	Alameda Ave at Fernwood Ave	$42M
Roscoe Blvd at Woodman Ave	$42M	Alameda Ave at Southern Ave	$42M
Roscoe Blvd at Goldwater Canyon Ave.	$42M	Alameda Ave at Firestone Blvd	$42M
Roscoe Blvd at Whitsett Ave	$42M	Alameda Ave at Nadeau St	$42M
Roscoe Blvd at Laurel Canyon Blvd (Dual)	$78M	Alameda Ave at Florence St	$42M
Roscoe Blvd/Tuxford Street at Webb Ave	$42M	Alameda Ave at Gage Ave	$42M
Tuxford St at Lankersham Blvd	$42M	Alameda Ave at Slauson Ave	$42M
Tuxford St at San Fernando Rd	$42M	Alameda Ave at Vernon Ave	$42M
Tuxford St at Glenoaks Blvd (dual)	$78M	Alameda Ave at Washington Blvd	$42M
La Tuna Canyon Rd at Sunland Blvd	$42M	Alameda Ave at Olympic Blvd	$42M
San Vicente Blvd at 26th St	$42M	Alameda Ave at 7th St	$42M
San Vicente Blvd at Barrington Ave	$42M	Alameda Ave at 6th St	$42M
San Vicente Blvd/Wilshire Blvd at Federal Ave	$42M	Alameda Ave at 4th St	$42M
Wilshire Blvd at Veteran Ave	$42M	Alameda Ave at 3rd St	$42M
Wilshire Blvd at Westwood Blvd	$42M	Alameda Ave at 1st St	$42M
Wilshire Blvd at Beverly Glen Blvd	$42M	Alameda Ave at Cesar Chavez Ave	$42M
Wilshire Blvd at SR 2/Santa Monica Blvd	$42M	Alameda Ave at College St	$42M
Santa Monica Blvd at Beverly Dr	$42M	Broadway at Daly St	$42M
Santa Monica Blvd at Doheny Dr	$42M	Pasadena Ave at Figueora St	$42M
Santa Monica Blvd at San Vicente Blvd	$42M	Figueora St at 52nd Ave.	$42M
Santa Monica Blvd at La Cienega Blvd	$42M	Figueora St at York Blvd	$42M
Santa Monica Blvd at Crescent Heights Blvd	$42M	Figueora St at Colorado Blvd	$42M
Santa Monica Blvd at Fairfax Ave	$42M	Ximeno Ave at Broadway	$42M
Santa Monica Blvd at La Brea Ave	$42M	Ximeno Ave at 3rd Street	$42M
Santa Monica Blvd at Highland Ave	$42M	Ximeno Ave at 4th St	$42M
Santa Monica Blvd at Cahuenga Blvd	$42M	Ximeno Ave at 7th St	$42M
Santa Monica Blvd at Vine St	$42M	Ximeno Ave at Anaheim St	$42M
Santa Monica Blvd at Wilton Place	$42M	Ximeno Ave at SR 1	$42M

Table C3: Managed Arterial Grade Separated Interchanges

Grade Separation	Cost	Grade Separation	Cost
Santa Monica Blvd at Western Ave	$42M	Ximeno Ave at Atherton St	$42M
Santa Monica Blvd at Normandie Ave	$42M	Ximeno Ave at Los Coyotes Diagonal	$42M
Santa Monica Blvd at Vermont St	$42M	Lakewood Blvd at Stearns St	$42M
Sunset Blvd at Silver Lake Blvd	$42M	Lakewood Blvd at Willow St	$42M
Sunset Blvd at Alvarado St	$42M	Lakewood Blvd at Spring St	$42M
Sunset Blvd at Glendale Blvd	$42M	Lakewood Blvd at Carson St	$42M
San Vicente Blvd at Huntington Dr	$42M	Lakewood Blvd at Del Amo Blvd	$42M
Garfield Ave at Atlantic Blvd / Huntington Dr	$42M	Lakewood Blvd at Candlewood St	$42M
Garfield Ave at Main St	$42M	Lakewood Blvd at South St	$42M
Las Tunas Dr at San Gabriel Blvd	$42M	Lakewood Blvd at Ashworth St	$42M
Las Tunas Dr at Rosemead Dr	$42M	Lakewood Blvd at Flower St	$42M
Las Tunas Dr at Temple City Blvd	$42M	Lakewood Blvd at Alondra Blvd	$42M
Las Tunas Dr at Baldwin Ave	$42M	Lakewood Blvd at Somerset Blvd	$42M
Live Oak Ave at Santa Anita Ave	$42M	Lakewood Blvd at Rosecrans Blvd	$42M
Live Oak Ave at Myrtle Ave	$42M	Lakewood Blvd at Imperial Blvd	$42M
Slauson Ave at La Cienega Blvd (dual)	$42M	Lakewood Blvd at Stewart and Gray Rd	$42M
Slauson Ave at South La Brea Ave	$42M	Lakewood Blvd at Firestone Blvd	$42M
Slauson Ave at Overhill Dr	$42M	Lakewood Blvd at Florence Ave	$42M
Slauson Ave at Crenshaw Blvd	$42M	Rosemead Blvd at Slauson Ave	$42M
Slauson Ave at Van Ness Ave	$42M	Rosemead Blvd at Washington Blvd	$42M
Slauson Ave at Western Ave (dual)	$78M	Rosemead Blvd at Mines Ave	$42M
Slauson Ave at Normandie Ave	$42M	Rosemead Blvd at Whittier Blvd	$42M
Slauson Ave at Vermont Ave	$42M	Rosemead Blvd at E. Beverly Blvd	$42M
Slauson Ave at Hoover St	$42M	Rosemead Blvd at Durfee Ave	$42M
Slauson Ave at Figueroa St.	$42M	Rosemead Blvd at Garvey Ave	$42M
Slauson Ave at Broadway	$42M	Rosemead Blvd at Valley Blvd	$42M
Slauson Ave at Main St	$42M	Rosemead Blvd at Mission Drive	$42M
Slauson Ave at San Pedro St	$42M	Rosemead Blvd at Las Tunas Dr	$42M
Slauson Ave at Avalon Blvd	$42M	Rosemead Blvd at Longden Ave	$42M
Slauson Ave at Central Ave	$42M	Rosemead Blvd at Duarte Rd	$42M
Slauson Ave at Hooper Ave	$42M	Rosemead Blvd at Huntington Dr	$42M
Slauson Ave at Compton Ave	$42M	Rosemead Blvd at California Blvd	$42M
Slauson Ave at Alameda St	$42M	Rosemead Blvd at Colorado Blvd	$42M
Slauson Ave at Santa Fe Ave	$42M	Rosemead Blvd at Foothill Blvd	$42M
Slauson Ave at Pacific Blvd	$42M	Rosemead Blvd at Sierra Madre Villa Ave	$42M
Slauson Ave at Miles Ave	$42M	Sierra Madre Villa Ave at Sierra Madre Villa Blvd	$42M
Slauson Ave at Maywood Ave	$42M	Western Ave at Miraleste Drive	$42M
Slauson Ave at Atlantic Blvd	$42M	Western Ave at First St.	$42M
Slauson Ave at Eastern Ave	$42M	Western Ave at Palos Verdes Dr.	$42M
Slauson Ave at Garfield Ave	$42M	Western Ave at SR 1	$42M
Slauson Ave at Telegraph Rd	$42M	Western Ave at Lomita Blvd	$42M
Telegraph Rd at Paramount Blvd	$42M	Western Ave at Sepulveda Blvd	$42M
Telegraph Rd at Rosemead Blvd/Lakewood Blvd (dual)	$78M	Western Ave at 223rd St	$42M
Telegraph Rd at Orr and Day Rd	$42M	Western Ave at Carson St	$42M
Telegraph Rd at Pioneer Blvd	$42M	Western Ave at Torrance Blvd	$42M
Telegraph Rd at Norwalk Ave	$42M	Western Ave at 190th St.	$42M
Telegraph Rd at Bloomfield Ave	$42M	Western Ave at 182nd St.	$42M
Telegraph Rd at Greenleaf Ave	$42M	Western Ave at Artesia Blvd	$42M
Telegraph Rd at Carmentia Rd	$42M	Western Ave at 166th St	$42M
Telegraph Rd at Florence Ave	$42M	Western Ave at Redondo Beach Blvd	$42M
Telegraph Rd at Colima Rd	$42M	Western Ave at Marine Ave	$42M
Telegraph Rd at Leffingwell Rd	$42M	Western Ave at Rosecrans Ave.	$42M
Imperial Highway at La Mirada Blvd	$42M	Western Ave at 135th St	$42M
Imperial Highway at Santa Gertrudes Ave	$42M	Western Ave at El Segundo Blvd	$42M
Imperial Highway at SR 39	$42M	Western Ave at Imperial Highway	$42M
Imperial Highway at Idaho St	$42M	Western Ave at 108th St	$42M
Imperial Highway at Euclid St	$42M	Western Ave at Century Blvd	$42M
Imperial Highway at Harbor Blvd	$42M	Western Ave at 92nd St.	$42M
Imperial Highway at Brea Blvd	$42M	Western Ave at Manchester Ave	$42M
Imperial Highway at State College Blvd	$42M	Western Ave at Florence Ave.	$42M
Imperial Highway at Associated Road	$42M	Western Ave at Gage Ave.	$42M
Imperial Highway at Kraemer Blvd	$42M	Western Ave at 54th St.	$42M

Table C3: Managed Arterial Grade Separated Interchanges

Grade Separation	Cost	Grade Separation	Cost
Imperial Highway at Valencia Ave	$42M	Western Ave at 48th St.	$42M
Valencia Ave at Birch St	$42M	Western Ave at Vernon Ave.	$42M
Chino Hills Parkway at Peyton Dr (Dual)	$78M	Western Ave at Martin Luther King Jr. Blvd	$42M
Chino Hills Parkway at Pipeline Ave	$42M	Western Ave at Exposition Blvd	$42M
Chino Hills Parkway at Ramona Ave	$42M	Western Ave at Jefferson Blvd	$42M
Chino Hills Parkway at Central Ave	$42M	Western Ave at Adams Blvd	$42M
Merrill Ave at Euclid Ave	$42M	Western Ave at Washington Blvd	$42M
Limonite Ave at Sumner Ave	$42M	Western Ave at Venice Blvd	$42M
Limonite Ave at Hamner Ave	$42M	Western Ave at W. Pico Blvd	$42M
Limonite Ave at Wineville Ave	$42M	Western Ave at Olympic Blvd	$42M
Limonite Ave at Etiwanda Ave	$42M	Western Ave at Oxford Ave.	$42M
Riverview Dr at Mission Blvd	$42M	Western Ave at Wilshire Blvd	$42M
Torrance Blvd at SR 1	$42M	Western Ave at 6th St.	$42M
Torrance Blvd at Prospect Ave	$42M	Western Ave at 3rd St.	$42M
Torrance Blvd at Anza Ave	$42M	Western Ave at Beverly Blvd	$42M
Torrance Blvd at Hawthorne Blvd	$42M	Western Ave at Melrose Ave.	$42M
Hawthorne Blvd at Carson St	$42M	Western Ave at Santa Monica Blvd	$42M
Carson St at Madrona Ave	$42M	Western Ave at Fountain Ave	$42M
Carson St at Maple Ave	$42M	Western Ave at Sunset Dr.	$42M
Carson St at Crenshaw Blvd	$42M	Western Ave at Prospect Ave	$42M
Carson St at Carbillo Ave	$42M	Western Ave at Franklin Ave	$42M
Carson St at Western Ave	$42M	Buena Vista Rd at Alameda Ave	$42M
Carson St at Normandie Ave	$42M	Buena Vista Rd at Olive Ave	$42M
Carson St at Vermont Ave	$42M	Buena Vista Rd at Magnolia Blvd	$42M
Carson St at Figueroa St	$42M	Buena Vista Rd at Burbank St.	$42M
Carson St at Main St	$42M	Buena Vista Rd at Victory Rd	$42M
Carson St at Delores St	$42M	Buena Vista Rd at Empire Ave.	$42M
Carson St at Avalon Blvd	$42M	Buena Vista Rd at San Fernando Blvd	$42M
Carson St at Wilmington Ave	$42M	Buena Vista Rd at Glen Oaks Blvd	$42M
Carson St at Santa Fe Ave	$42M	Glen Oaks Blvd at Sunland Blvd	$42M
Bixby Rd at Long Beach Blvd	$42M	Glen Oaks Blvd at Penrose St	$42M
Bixby at Atlantic Ave	$42M	Glen Oaks Blvd at Sheldon St	$42M
Carson St at Orange Ave	$42M	Glen Oaks Blvd at Osbourne St	$42M
Carson St at Cherry Ave	$42M	Glen Oaks Blvd at Van Nuys Blvd	$42M
Carson St at Paramount Blvd	$42M	Glen Oaks Blvd at Paxton St	$42M
Carson St at Lakewood Blvd	$42M	Glen Oaks Blvd at Vaughn St	$42M
Carson St at Clark Ave	$42M	Glen Oaks Blvd at Arroyo St.	$42M
Carson St at Bellflower Blvd	$42M	Glen Oaks Blvd at Macclay St	$42M
Carson St at Woodruff Ave	$42M	Glen Oaks Blvd at Hubbard St	$42M
Carson St at Palo Verde Ave	$42M	Glen Oaks Blvd at Sayre St.	$42M
Carson St at Pioneer Blvd	$42M	Glen Oaks Blvd at Polk St.	$42M
Lincoln Ave at Norwalk St	$42M	Glen Oaks Blvd at Tyler St.	$42M
Lincoln Ave at Moody St	$42M	Glen Oaks Blvd at Bledsoe St	$42M
Lincoln Ave at Walker St	$42M	Glen Oaks Blvd at Roxford St	$42M
Lincoln Ave a Valley View St	$42M	Beach Blvd at Atlanta Ave	$42M
Lincoln Ave at Knott Ave	$42M	Beach Blvd at Indianapolis Ave.	$42M
Lincoln Ave at Western Ave	$42M	Beach Blvd at Adams Ave	$42M
Lincoln Ave at Beach Blvd (dual)	$78M	Beach Blvd at Indianapolis Ave	$42M
Lincoln Ave at Dale Ave	$42M	Beach Blvd at Adams Ave	$42M
Lincoln Ave at Magnolia St	$42M	Beach Blvd at Yorktown Ave	$42M
Lincoln Ave at Gilbert St	$42M	Beach Blvd at Garfield Ave	$42M
Lincoln Ave at Brookhurst St	$42M	Beach Blvd at Ellis Ave	$42M
Lincoln Ave at Euclid St	$42M	Beach Blvd at Talbert Ave	$42M
Euclid St at Broadway	$42M	Beach Blvd at Slater Ave	$42M
Euclid St at Ball Rd	$42M	Beach Blvd at Heil Ave	$42M
Ball Rd at Disneyland Dr	$42M	Beach Blvd at Edinger Ave	$42M
Ball Rd at Harbor Blvd	$42M	Beach Blvd at Center Ave	$42M
Ball Rd at Anaheim Blvd	$42M	Beach Blvd at McFadden Ave	$42M
Ball Rd at State College Blvd	$42M	Beach Blvd at Bolsa Ave	$42M
Taft Ave at N Batavia St	$42M	Beach Blvd at Hazard Ave.	$42M
Taft Ave at Glassell St	$42M	Beach Blvd at Westminster Ave	$42M
Taft Ave at Cambridge St	$42M	Beach Blvd at Trask Ave.	$42M

Table C3: Managed Arterial Grade Separated Interchanges

Grade Separation	Cost	Grade Separation	Cost
Taft Ave at Tustin St	$42M	Beach Blvd at Garden Grove Blvd	$42M
Taft Ave at Santiago Blvd	$42M	Beach Blvd at Lampson Ave	$42M
E Santiago Canyon Rd at Cannon Rd	$42M	Beach Blvd at Chapman Ave	$42M
E Santiago Canyon Rd at Chapman Rd	$42M	Beach Blvd at Orangewood Ave	$42M
Warner Ave at Graham St	$42M	Beach Blvd at Katlia Ave	$42M
Warner Ave at Springdale St	$42M	Beach Blvd at Cerritos Ave	$42M
Warner Ave at Edwards St	$42M	Beach Blvd at Bali Rd	$42M
Warner Ave at Goldenwest St	$42M	Beach Blvd at Orange Ave	$42M
Warner Ave at Gothard St	$42M	Beach Blvd at Crescent Ave	$42M
Warner Ave at Beach Blvd (dual)	$78M	Beach Blvd at La Palma Ave.	$42M
Warner Ave at Newland St	$42M	Beach Blvd at Artesia Blvd	$42M
Warner Ave at Magnolia St	$42M	Beach Blvd at Malvern Ave	$42M
Warner Ave at Bushard St	$42M	Beach Blvd at Rosecrans Ave	$42M
Warner Ave at Brookhurst St	$42M	Beach Blvd at Imperial Highway	$42M
Warner Ave at Euclid St	$42M	Beach Blvd at Lambert Rd	$42M
Warner Ave at Newhope St	$42M	Beach Blvd at El Camino Real	$42M
Warner Ave at Harbor Blvd	$42M	Beach Blvd at Whittier Blvd	$42M
Warner Ave at Fairview St	$42M	Beach Blvd at Gregory Lane	$42M
Warner Ave at Raitt St	$42M	Hacienda Rd at Colima Rd	$42M
Warner Ave at Bristol St	$42M	Azusa Ave at Colima Rd	$42M
Warner Ave at Flower St	$42M	Azusa Ave at Gale Ave	$42M
Warner Ave at Main St	$42M	Azusa Ave at Arenth Ave	$42M
Warner Ave at Grand Ave	$42M	Azusa Ave at Valley Blvd	$42M
Red Hill Ave at Edinger Ave	$42M	Azusa Ave at Temple Ave	$42M
Tustin Ranch Rd at Walnut Ave	$42M	Azusa Ave at Amra Rd	$42M
Tustin Ranch Rd at El Camino Real	$42M	Azusa Ave at Merced Ave	$42M
Tustin Ranch Rd at Bryan Ave	$42M	Azusa Ave at Vine St	$42M
Tustin Ranch Rd at Irvine Blvd	$42M	Azusa Ave at Cameron Ave	$42M
Portola Parkway at Jamboree Rd	$42M	Azusa Ave at Workman Ave	$42M
Crown Valley Parkway at Camino Del Avion	$42M	Azusa Ave at Rowland St	$42M
Alicia Parkway at Niguel Rd	$42M	Azusa Ave at Puente Ave	$42M
Alicia Parkway at Aliso Creek Rd	$42M	Azusa Ave at Badillo St	$42M
Alicia Parkway at Pacific Park Dr	$42M	Azusa Ave at San Bernardino Rd	$42M
Alicia Parkway at Moulton Parkway	$42M	Azusa Ave at Cypress St	$42M
Alicia Parkway at Paseo De Valencia	$42M	Azusa Ave at Arrow Highway	$42M
Alicia Parkway at Muirlands Blvd	$42M	Azusa Ave at Gladstone St	$42M
Alicia Parkway at Jeronimo Rd	$42M	Azusa Ave at 1st St	$42M
Alicia Parkway at Trabuco Rd	$42M	Azusa Ave at 5th St	$42M
Alicia Parkway at Marguerite Parkway	$42M	Azusa Ave at Foothill Blvd	$42M
Alicia Parkway at Olympiad Rd	$42M	Azusa Ave at Sierra Madre Ave	$42M
Santa Margarita Parkway at Avenida De Las Flores	$42M	Fairmont Blvd at La Palma Ave	$42M
Santa Margarita Parkway at Antonio Parkway	$42M	Fairmont Blvd at Esperanza Rd	$42M
SR 74 at Perris Blvd	$42M	Fairmont Blvd at Yorba Linda Blvd	$42M
SR 74 at SR 79 (Dual)	$78M	Fairmont Blvd at Bastanchury Rd	$42M
SR 74 at Warren Rd	$42M	Carbon Canyon Rd at Chino Hills Parkway	$42M
SR 74 at Sanderson Ave	$42M	Chino Hills Parkway at Grand Ave	$42M
SR 74 at Kirby St	$42M	Peyton Dr at Eucalyptus Ave	$42M
SR 74 at Lyon Ave	$42M	Peyton Dr at Grand Ave	$42M
SR 74 at Palm Ave	$42M	Peyton Dr at Chino Ave	$42M
SR 74 at State St	$42M	Towne Ave at Philadelphia St	$42M
SR 74 at San Jacinto Rd	$42M	Towne Ave at Lexington Ave	$42M
SR 23 at Agoura St	$42M	Towne Ave at Franklin Ave	$42M
SR 23S at US 101	$42M	Towne Ave at Phillips Blvd	$42M
Westlake Blvd at Thousand Oaks Rd	$42M	Towne Ave at Mission Blvd	$42M
Madera Rd at Tierra Rejada Rd	$42M	Towne Ave at Holt Ave	$42M
Madera Rd at Easy St	$42M	Towne Ave at Arrow Highway	$42M
SR 1/27 at SR 107	$42M	Towne Ave at Bonita Ave	$42M
SR 1/27 at Calle Mayor	$42M	Towne Ave at Foothill Blvd	$42M
SR 1/27 at Palos Verdes Blvd	$42M	Euclid Ave at Pine Ave	$42M
SR 1/27 at Torrance Blvd	$42M	Euclid Ave at Edison Ave	$42M
SR 1/27 at Diamond St	$42M	Euclid Ave at Schaefer Ave	$42M
SR 1/27 at Herondo St	$42M	Euclid Ave at Chino Ave	$42M

Table C3: Managed Arterial Grade Separated Interchanges

Grade Separation	Cost	Grade Separation	Cost
SR 1/27 at Artesia Blvd	$42M	Euclid Ave at Riverside Dr	$42M
SR 1/27 at Manhattan Beach Blvd	$42M	Euclid Ave at Walnut St	$42M
SR 1/27 at Rosecrans Ave	$42M	Euclid Ave at Philadelphia St	$42M
SR 1/27 at El Segundo Blvd	$42M	Euclid Ave at Francis St	$42M
SR 1/27 at Grand Ave	$42M	Euclid Ave at Phillips St	$42M
SR 1/27 at Imperial Highway	$42M	Euclid Ave at W. Mission Blvd	$42M
SR 1/27 at Manchester Ave	$42M	Euclid Ave and E Holt Blvd	$42M
SR 1/27 at Jefferson Blvd	$42M	Euclid Ave at D St	$42M
SR 1/27 at Washington Blvd	$42M	Euclid Ave at 4th St	$42M
SR 1/27 at Venice Blvd	$42M	Euclid Ave at 6th St	$42M
SR 1/27 at Rose Ave	$42M	Euclid Ave at 8th St	$42M
SR 1/27 at Ocean Park Blvd	$42M	Euclid Ave at Arrow Highway	$42M
SR 1/27 at Pico Blvd	$42M	Euclid Ave at Foothill Blvd	$42M
SR 1/27 at Chautauqua Blvd and Channel Rd	$42M	Euclid Ave at 13th St	$42M
SR 1/27 at Ventura Blvd	$42M	Euclid Ave at 16th St	$42M
SR 1/27 at Burbank Blvd	$42M	Euclid Ave at 19th St	$42M
SR 1/27 at Oxnard St	$42M	Piedras Rd at Santa Rosa Mine Rd	$42M
SR 1/27 at Victory Blvd	$42M	Van Buren Blvd at Victoria Ave	$42M
SR 1/27 at Vanowen St	$42M	Van Buren Blvd at Indiana Ave	$42M
SR 1/27 at Sherman Way	$42M	Van Buren Blvd at Magnolia Ave	$42M
SR 1/27 at Saticoy St	$42M	Van Buren Blvd at California Ave	$42M
SR 1/27 at Plummer St	$42M	Van Buren Blvd at Jackson St	$42M
SR 1/27 at Larson St	$42M	Van Buren Blvd at Arlington Ave	$42M
SR 1/27 at Devonshire St	$42M	Van Buren Blvd at Jurupa Rd	$42M
La Cienega Blvd at Centinela Ave	$42M	Jurupa Rd at Pedley Rd	$42M
La Cienega Blvd at La Tijera Blvd	$42M	Jurupa Rd at Camino Real	$42M
La Cienega Blvd at Rodeo Rd	$42M	Pedley Rd at Mission Blvd	$42M
La Cienega Blvd at Jefferson Blvd	$42M	Sierra Ave at Santa Anna Ave	$42M
La Cienega Blvd at Washington Blvd	$42M	Sierra Ave at Slover Ave	$42M
La Cienega Blvd at Venice Blvd	$42M	Sierra Ave at Valley Blvd	$42M
La Cienega Blvd at Cadillac Ave	$42M	Sierra Ave at San Bernardino Ave	$42M
La Cienega Blvd at at Pico Blvd	$42M	Sierra Ave at Randall Ave	$42M
La Cienega Blvd at Olympic Blvd	$42M	Sierra Ave at Merrill Ave	$42M
La Cienega Blvd at Wilshire Blvd	$42M	Sierra Ave at Arrow Blvd	$42M
La Cienega Blvd at San Vicente Blvd	$42M	Sierra Ave at Foothill Blvd	$42M
La Cienega Blvd at 3rd St	$42M	Sierra Ave at Miller Ave	$42M
La Cienega Blvd at Beverly Blvd	$42M	Sierra Ave at Baseline Rd	$42M
La Cienega Blvd at Melrose Ave	$42M	Sierra Ave at Highland Ave	$42M
La Cienega Blvd at Santa Monica Blvd	$42M	Sierra Ave at Sierra Lakes Parkway	$42M
Laurel Canyon Blvd at Mulholland Dr	$42M	SR 79 at Margarita Rd	$42M
Laurel Canyon Blvd at Ventura Blvd	$42M	SR 79 at Murrieta Hot Springs Rd	$42M
Laurel Canyon Blvd at Moorpark St	$42M	SR 79 at Leon Rd	$42M
Laurel Canyon Blvd at Riverside Dr	$42M	SR 79 at Scott Rd	$42M
Laurel Canyon Blvd at Magnolia Blvd	$42M	SR 79 at Domenigoni Parkway	$42M
Laurel Canyon Blvd at Chandler Blvd	$42M	SR 79 at Simpson Rd	$42M
Laurel Canyon Blvd at Burbank Blvd	$42M	Hansen Road at Ramona Expressway	$42M
Laurel Canyon Blvd at Oxnard St	$42M	San Mateo St at Brookside Ave	$42M
Laurel Canyon Blvd at Victory Blvd	$42M	Tennessee St at Slate St.	$42M
Laurel Canyon Blvd at Vanowen St	$42M	Tennessee St at Redlands Blvd	$42M
Laurel Canyon Blvd at Sherman Way	$42M	Tennessee St at Colton St	$42M
Laurel Canyon Blvd at Saticoy St	$42M	**Total**	**$24.3B**
Laurel Canyon Blvd at Strathern St	$42M		
Sheldon St at San Fernando Blvd	$42M		

Table C4: New Roadway Sections/New Bridges (New Alignments)			
Road	**From**	**To**	**Cost**
I-710 - Bixby Rd. Connector (1.5 miles, 9 lane miles)	I-710	Bixby Rd at Country Club Rd	$216.9M
Tustin St - N. Highland St Connector (0.2 miles, 1.2 lane miles)	Taft Ave and Tustin St	Taft Ave and N. Highland St	$29.9M
Westlake Blvd – Wood Ranch Parkway Connector (2.0 miles, 8.0 lane miles)	Westlake Blvd 0.1 mile west of Oak Valley Lane	Wood Ranch Parkway at Long Canyon Rd	$192.8M
Rosecrans Connector (0.2 miles, 0.8 lane miles)	Alameda St	Rosecrans Blvd	$19.3M
Western Ave Missing Link (7.6 miles, 30.4 lane miles)	Los Feliz Blvd	Buena Vista St at SR 134	$732.6M
Hacienda Ave Extension (0.4 miles, 2.4 lane miles)	Beach Blvd at Gregory Lane	Whittier Blvd and Hacienda Ave	$53.3M
Fairmont Blvd Extension (2.5 miles, 15.0 lane miles)	Fairmont Blvd at Quarter House Rd	Carbon Canyon Rd at Olindo Dr	$361.5M
Juniper Springs Extension (2.5 miles, 15.0 lane miles)	SR 74	Juniper Springs Curve	$361.5M
SR 90 bridge (0.4 miles, 2.4 lane miles)	West of Mindanao Way	East of Mindanao Way	$57.8M
Total			**$2.0B**

Table C5: List of Managed Lane Components			
Managed Arterial	**Improvement**	**Managed Arterial**	**Improvement**
Roscoe Blvd	From Valley Circle Blvd to SR 27 convert parking lanes to travel lanes (2.3 miles, 4.6 lane miles)	Sheldon St	Build managed grade separation at San Fernando Rd
Roscoe Blvd	Build managed grade separation at Fallbrook Ave	Sheldon St	Build managed grade separation at Branford St
Roscoe Blvd	Add 1 lane in each direction from Haskell Ave to Landon Ave	Sheldon St	Build managed grade separation at Osborne St
Roscoe Blvd	Build managed grade separation at SR 27	Sheldon St	Build managed grade separation at Van Nuys Blvd
Roscoe Blvd	Build managed grade separation at Canoga Ave	San Fernando Rd	From Sheldon St to La Rue St add 1 lane in each direction (3.6 miles, 7.2 lane miles)
Roscoe Blvd	Build managed grade separation at De Soto Ave	San Fernando Rd	Build managed grade separation at Paxton St
Roscoe Blvd	Build managed grade separation at Mason Ave	San Fernando Rd	Rebuild SR 118 Interchange
Roscoe Blvd	Build managed grade separation at Winnetka Ave	San Fernando Rd/Truman St	Build managed grade separation at Hubbard St
Roscoe Blvd	Build managed grade separation at Corbin Ave	San Fernando Rd/Truman St	From La Rue St to Bleeker St convert two-way streets to two way one streets (1.4 miles, 11.2 lane miles)
Roscoe Blvd	Build managed grade separation at Tampa Ave	San Fernando Rd	Build managed grade separation at Polk St
Roscoe Blvd	Build managed grade separation at Wilbur Ave	San Fernando Rd	Build managed grade separation at Roxford St
Roscoe Blvd	Build managed grade separation at Reseda Blvd	San Fernando Rd	From Bleeker St to I-5 add 1 lane in each direction (2.7 miles, 5.4 lane miles)
Roscoe Blvd	Build managed grade separation at Lindley Ave	SR 47	Build managed grade separation at Anaheim St
Roscoe Blvd	Build managed grade separation at Balboa Blvd	SR 47	From Anaheim St to Alameda St (convert parking lanes to travel lanes 0.4 mile, 0.8 lane miles)
Roscoe Blvd	Build managed grade separation at Woodley Ave	Alameda St	From Alameda St to SR 1 Convert northbound parking lane to travel lane (0.3 miles, 0.3 lane miles)
Roscoe Blvd	Build managed grade separation at I-405 Interchange	Alameda St	From north of Sepulveda Blvd to South of 223rd St. Add 1 lane in each direction (1.2 miles, 2.4 lane miles)
Roscoe Blvd	Build managed grade separation at Sepulveda Blvd	Alameda St	Rebuild I-405 Interchange
Roscoe Blvd	Build managed grade separation at Van Nuys Blvd	Alameda St	From north of I-405 to SR 91 convert parking lanes to travel lanes (3.2 miles, 6.4 lane miles)
Roscoe Blvd	Build managed grade separation at Woodman Ave	Alameda St	Build managed grade separation at Santa Fe Ave
Roscoe Blvd	Build managed grade separation at Goldwater Canyon Ave.	Alameda St	Rebuild SR 91 Interchange
Roscoe Blvd	Rebuild SR 170 Interchange	Alameda St	From SR 91 to Nadeau St add 1 travel lane in each direction 6.6 miles, 13.2 lane miles)
Roscoe Blvd	From SR 170 to Sunland Canyon Blvd convert parking lanes to travel lanes (2.8 miles, 5.6 lane miles)	Alameda St	Build managed grade separation at Greenleaf Blvd
Roscoe Blvd	Build managed grade separation at Whitsett Ave	Alameda St	Build managed grade separation at Alondra Blvd
Roscoe Blvd	Build managed grade separation at Laurel Canyon Blvd	Alameda St	Build managed grade separation at Compton Blvd
Roscoe Blvd	Build managed grade separation at Webb Ave	Alameda St	Build new connector intersecting with Rosecrans Dr
Roscoe Blvd	Build managed grade separation at Lankershim Blvd	Alameda St	Build managed grade separation at El Segundo Blvd
Roscoe Blvd	Rebuild I-5 Interchange	Alameda St	Build new Interchange at I-105
Roscoe Blvd	Build managed grade separation at San Fernando Rd	Alameda St	Build managed grade separation at Imperial Highway
Roscoe Blvd	Build managed grade separation at Glenoaks Blvd	Alameda St	Build managed grade separation at Fernwood Ave
Roscoe Blvd	Build dual managed grade separations at Sunland Blvd	Alameda St	Build managed grade separation at Southern Ave
Roscoe Blvd	From Sunland Canyon Blvd to Elbon St add 1 lane in each direction, convert parking lanes to travel lanes (1.8	Alameda St	Build managed grade separation at Firestone Blvd

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
	miles, 7.2 lane miles)		
Roscoe Blvd	From Elbon St to I-210 convert parking lanes to travel lanes (2.5 miles, 5.0 lane miles)	Alameda St	Build managed grade separation at Nadeau St
Roscoe Blvd	Rebuild I-210 Interchange	Alameda St	From Nadeau St to E 76th St, add 1 travel lane northbound, convert parking lane southbound (0.3 miles, 0.3 new lane miles, 0.3 converted lane miles)
Tujunga Canyon Rd	From La Tuna Canyon Rd to Foothill Blvd add 1 lane in each direction (1.0 mile, 2.0 lane miles)	Alameda St	From E 76th St to US 101 add 1 lane in each direction, (5.7 miles, 11.4 lane miles)
San Vicente Blvd	Build managed grade separation at 26th St	Alameda St	Build managed grade separation at Florence St
San Vicente Blvd	From 26th St to Wilshire Blvd (add 1 lane in each direction, 1.0 mile, 2.0 lane miles)	Alameda St	Build managed grade separation at Gage Ave
San Vicente Blvd	Build managed grade separation at Barrington Ave	Alameda St	Build managed grade separation at Slauson Ave
Wilshire Blvd	Build managed grade separation at Federal Ave	Alameda St	Build managed grade separation at Vernon Ave
Wilshire Blvd	Build managed grade separation at Veteran Ave	Alameda St	Build managed grade separation at Washington Blvd
Wilshire Blvd	Build managed grade separation at Westwood Blvd	Alameda St	Rebuild I-10 Interchange
Wilshire Blvd	Build managed grade separation at Beverly Glen Blvd	Alameda St	Build managed grade separation at Olympic Blvd
Wilshire Blvd	Build managed grade separation at SR 2/Santa Monica Blvd	Alameda St	Build managed grade separation at 7th St
Santa Monica Blvd	From Wilshire Blvd to Doheny Dr add 1 lane in each direction (1.5 miles, 3.0 lane miles)	Alameda St	Build managed grade separation at 6th St
Santa Monica Blvd	Build managed grade separation at Beverly Dr	Alameda St	Build managed grade separation at 4th St
Santa Monica Blvd	Build managed grade separation at Doheny Dr	Alameda St	Build managed grade separation at 3rd St
Santa Monica Blvd	From Doheny Dr to Sunset Blvd, add 1 lane total, convert parking lane to travel lane (6.5 miles, 13.0 lane miles)	Alameda St	Build managed grade separation at 1st St
Santa Monica Blvd	Build managed grade separation at North San Vicente Blvd	Alameda St	Rebuild US 101 Interchange
Santa Monica Blvd	Build managed grade separation at La Cienega Blvd	Alameda St	Build managed grade separation at Cesar Chavez Ave
Santa Monica Blvd	Build managed grade separation at Crescent Heights Blvd	Alameda St	From Main St to Elmyra St (0.5 miles, 0.5 lane miles) add 1 lane in northbound direction
Santa Monica Blvd	Build managed grade separation at Fairfax Ave	Alameda St	Build managed grade separation at College St
Santa Monica Blvd	Build managed grade separation at La Brea Ave	Spring St	From Elmyra St to Mesnagers St, add 1 lane in each direction (0.3 mile, 0.6 lane miles)
Santa Monica Blvd	Build managed grade separation at Highland Ave	Spring St	From Mesnagers St to 18th Ave Add 2 lanes in each direction (0.4 mile, 1.6 lane miles)
Santa Monica Blvd	Build managed grade separation at Cahuenga Blvd	Broadway	Rebuild I-5 Interchange
Santa Monica Blvd	Build managed grade separation at Vine St	Broadway	Build managed grade separation at Daly Ave
Santa Monica Blvd	Build managed grade separation at Wilton Place	Daly St	From Broadway to Pasadena Ave (0.2 mile, 0.4 lane mile) add 1 lane in each direction
Santa Monica Blvd	Build managed grade separation at Western Ave	Pasadena Ave	From Daly St to French Ave (0.8 mile, 3.2 lane mile) add 2 lanes in each direction
Santa Monica Blvd	Rebuild US 101 Interchange	Pasadena Ave	Build Interchange at SR 110
Santa Monica Blvd	Build managed grade separation at Normandy Ave	Pasadena Ave	From French Ave to Figueroa St (0.2 mile, 0.4 lane mile) add 1 lane in each direction
Santa Monica Blvd	Build managed grade separation at Vermont St	Pasadena Ave	Build managed grade separation at Figueroa St
Sunset Blvd	From Santa Monica Blvd to SR 110 convert parking lanes to travel lanes (3.0 miles, 6.0 lane miles)	Figueroa St	From Pasadena Ave to York Blvd (2.4 miles, 4.8 lane miles) convert parking lanes to travel lanes
Sunset Blvd	Build managed grade separation at Silver Lake Blvd	Figueroa St	Build managed grade separation at 52nd Ave
Sunset Blvd	Build managed grade separation at Alvarado St	Figueroa St	Build managed grade separation at York Blvd
Sunset Blvd	Build managed grade separation at Glendale Blvd	Figueroa St	Build managed grade separation at Colorado Blvd
Sunset Blvd	Rebuild SR 110 Interchange	Figueroa St	From York Blvd to Colorado Blvd (1.7 mile, 3.4 lane miles) add 1 lane in each direction
Grevalia St	Rebuild SR 110 Interchange at Fair Oaks Ave	Figueroa St	From Colorado Blvd to ramp to SR 134E add 2 lanes in each direction (0.1 mile, 0.4 lane miles)
Grevalia St	From SR 110 to Stratford Ave add 2 lanes in each direction (0.3 mile, 1.2 lane mile)	Figueroa St	From ramp to SR 134E to SR 134 interchange, add 1 lane in each direction
Garfield Ave	From Stratford Ave to Huntington Dr add 2 lanes in each direction (1.1 miles, 4.4 lane miles)	Figueroa St	Rebuild Interchange at SR 143
Garfield Ave	Build managed grade separation at Huntington Dr	Ximeno Ave	From Livingston St to Anaheim St (1.4 miles, 2.8 converted lane miles, 2.8 new lane miles) convert parking lanes to travel lanes,

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
			add 1 new lane in each direction
Garfield Ave	Build managed grade separation at Atlantic Blvd	Ximeno Ave	Build managed grade separation at Broadway
Garfield Ave	Build managed grade separation at Main St	Ximeno Ave	Build managed grade separation at 3^{rd} St.
Main St/Las Tunas Dr	From Garfield Ave to San Gabriel Blvd convert parking lanes to travel lanes (2.2 miles, 4.4 lane miles)	Ximeno Ave	Build managed grade Separation at 4^{th} St.
Las Tunas Dr	Build managed grade separation at San Gabriel Blvd	Ximeno Ave	Build managed grade separation at 7^{th} St
Las Tunas Dr	Build managed grade separation at Rosemead Dr	Ximeno Ave	Build managed grade separation at Anaheim St
Las Tunas Dr	From Rosemead Blvd to Longden Ave convert parking lanes to travel lanes (4.4 miles, 8.8 lane miles)	Ximeno Ave	From Anaheim St to 15^{th} St convert parking lanes to travel lanes, Add 1 new northbound travel lane 0.2 miles, 0.4 converted lane miles, 0.2 new lane miles)
Las Tunas Dr	Build managed grade separation at Temple City Blvd	Ximeno Ave	From 15^{th} St to Los Coyotes Diagonal convert parking lanes to travel lanes (0.5 miles, 1.0 converted lanes, 0 new lane miles)
Las Tunas Dr	Build managed grade separation at Baldwin Ave	Ximeno Ave	Build managed grade separation at SR 1
Live Oak Ave	Build managed grade separation at Santa Anita Ave	Ximeno Ave	Build managed grade separation at Atherton St
Live Oak Ave.	Build managed grade separation at Myrtle Ave	Ximeno Ave	Build managed grade separation at Los Coyotes Diagonal
SR 90	Build interchange at Mindanao Way	Rosada St	Add 2 new travel lanes in each direction from Los Coyotes Diagonal to Lakewood Blvd (0.2 miles, 0.8 new lane miles)
Slauson Ave	Build managed grade separation at South La Brea Ave	Lakewood Blvd	Convert northbound parking lane to travel lane from Traffic Circle to E Stearns St (0.3 miles, 0.3 converted lane miles, 0 new lane miles)
Slauson Ave	Build managed grade separation at Overhill Dr	Lakewood Blvd	Build managed grade separation at Stearns St
Slauson Ave	From Alviso St to Ruthelen St add 1 lane total, convert parking lane to travel lane (1.8 miles, 3.6 lane miles)	Lakewood Blvd	Build managed grade separation at Willow St
Slauson Ave	Build managed grade separation at Crenshaw Blvd	Lakewood Blvd	Rebuild I-405 Interchange
Slauson Ave	Build managed grade separation at Van Ness Ave	Lakewood Blvd	Build managed grade separation at Spring St
Slauson Ave	From Ruthelen St to Santa Fe Ave add 1 lane in each direction (4.7 miles, 9.4 lane miles)	Lakewood Blvd	Build managed grade separation at Carson St
Slauson Ave	Build dual managed grade separation at Western Ave	Lakewood Blvd	Convert parking lanes to travel lanes from Carson St to Del Amo Blvd (1.6 miles, 3.2 converted lane miles, 0 new lane miles)
Slauson Ave	Build managed grade separation at Normandie Ave	Lakewood Blvd	Build managed grade separation at Del Amo Blvd
Slauson Ave	Build managed grade separation at Vermont Ave	Lakewood Blvd	Build managed grade separation at Candlewood St
Slauson Ave	Build managed grade separation at Hoover St	Lakewood Blvd	Build managed grade separation at South St
Slauson Ave	Build managed grade separation at Figueroa St	Lakewood Blvd	Build managed grade separation at Ashworth St
Slauson Ave	Rebuild I-110 Interchange	Lakewood Blvd	Rebuild SR 91 Interchange
Slauson Ave	Build managed grade separation at Broadway	Lakewood Blvd	Convert parking lanes to travel lanes From Park St to I-105 (3.8 miles, 7.6 converted lane miles, 0 new lane miles)
Slauson Ave	Build managed grade separation at Main St	Lakewood Blvd	Build managed grade separation at Flower St
Slauson Ave	Build managed grade separation at San Pedro St	Lakewood Blvd	Build managed grade separation at Alondra Blvd
Slauson Ave	Build managed grade separation at Avalon Blvd	Lakewood Blvd	Build managed grade separation at Somerset Blvd
Slauson Ave	Build managed grade separation at Central Ave	Lakewood Blvd	Build managed grade separation at Rosecrans Blvd
Slauson Ave	Build managed grade separation at Hooper Ave	Lakewood Blvd	Rebuild I-105 Interchange
Slauson Ave	Build managed grade separation at Compton Ave	Lakewood Blvd	Build managed grade separation at Imperial Highway
Slauson Ave	Build managed grade separation at Alameda St	Lakewood Blvd	Build managed grade separation at Stewart and Gray Rd
Slauson Ave	Build managed grade separation at Santa Fe Ave	Lakewood Blvd	Build managed grade separation at Firestone Blvd
Slauson Ave	From Santa Fe Ave to Alamo Ave convert parking lanes to travel lanes (3.2 miles, 6.4 lane miles)	Lakewood Blvd	Build managed grade separation at Florence Ave
Slauson Ave	Build managed grade separation at Pacific Blvd	Lakewood Blvd	Convert parking lanes to travel lanes from Florence to I-5 (1.0 miles, 2.0 converted lane miles, 0 new lane miles)
Slauson Ave	Build managed grade separation at Miles Ave	Lakewood Blvd	Rebuild I-5 Interchange
Slauson Ave	Build managed grade separation at Maywood Ave	Rosemead Blvd	Convert parking lanes to travel lanes from E Telegraph Rd to Gallatin Rd (4.3 miles, 8.6 converted lane miles, 0 new miles)
Slauson Ave	Build managed grade separation at Atlantic Blvd	Rosemead Blvd	Build managed grade separation at Slauson Ave
Slauson Ave	From Alamo Ave to I-710 add 1 lane in each direction (0.3 miles, 0.6 lane miles)	Rosemead Blvd	Build managed grade separation at Washington Blvd
Slauson Ave	Rebuild I-710 Interchange	Rosemead Blvd	Build managed grade separation at Mines Ave
Slauson Ave	Build managed grade separation at Eastern Ave	Rosemead Blvd	Build managed grade separation at Whittier Blvd
Slauson Ave	Build managed grade separation at Garfield Ave	Rosemead Blvd	Build managed grade separation at East Beverly Blvd
Slauson Ave	From Garfield Ave to Greenwood Ave convert parking lanes to travel lanes (0.7 miles, 1.4 lane miles)	Rosemead Blvd	Add 1 travel lane in each direction from Gallatin Rd to SR 60 (4.5 miles, 9.0 new lane miles)
Slauson Ave	Rebuild I-5 Interchange	Rosemead Blvd	Build managed grade separation at Durfee Ave
Slauson Ave	Build managed grade separation at Telegraph Rd	Rosemead Blvd	Rebuild SR 60 Interchange
Telegrpah Rd	From Slauson Ave to Tweedy Ln add 1 lane in each direction (0.5 mile, 1.0 lane mile)	Rosemead Blvd	Build managed grade separation at Garvey Ave
Telegraph Rd	Build managed grade separation at Paramount Blvd	Rosemead Blvd	Rebuild I-10 Interchange
Telegraph Rd	Build dual managed grade separation at Rosemead Blvd	Rosemead Blvd	Convert parking lanes to travel lanes from Marshall St to Sierra

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
			Madre Villa Ave (5.9 miles, 11.8 converted lane miles)
Telegraph Rd	From True Ave to I-605 add 1 lane in each direction (0.3 miles, 0.6 lane miles)	Rosemead Blvd	Build managed grade separation at Valley Blvd
Telegraph Rd	Rebuild I-605 Interchange	Rosemead Blvd	Build managed grade separation at Mission Dr
Telegraph Rd	Build managed grade separation at Orr and Day Rd	Rosemead Blvd	Build managed grade separation at Las Tunas Dr
Telegraph Rd	Build managed grade separation at Pioneer Blvd	Rosemead Blvd	Build managed grade separation at Longden Ave
Telegraph Rd	Build managed grade separation at Norwalk Ave	Rosemead Blvd	Build managed grade separation at Duarte Rd
Telegraph Rd	Build managed grade separation at Bloomfield Ave	Rosemead Blvd	Build managed grade separation at Huntington Drive
Telegraph Rd	Build managed grade separation at Greenleaf Ave	Rosemead Blvd	Build managed grade separation at California Blvd
Telegraph Rd	Build managed grade separation at Carmentia Rd	Rosemead Blvd	Build managed grade separation at Colorado Blvd
Telegraph Rd	Build managed grade separation at Florence Ave	Rosemead Blvd	Rebuild I-210 Interchange
Telegraph Rd	Build managed grade separation at Colima Rd	Rosemead Blvd	Build managed grade separation at Foothill Blvd
Telegraph Rd	Build managed grade separation at Leffingwell Rd	Rosemead Blvd	Build managed grade separation at Sierra Madre Villa Blvd
Imperial Highway	Build managed grade separation at La Mirada Blvd	Sierra Madre Villa Ave	Build managed grade separation at East Sierra Madre Villa Blvd
Imperial Highway	Build managed grade separation at Santa Gertrudes Ave	Sierra Madre Villa Ave	Add 1 lane to both ways From Rosemead Blvd to East Sierra Madre Blvd (0.2 miles, 0.4 miles, 0.4 new lane miles)
Imperial Highway	Build managed grade separation at SR 39	Western Ave	Build managed grade separation at S Miraleste Drive
Imperial Highway	Build managed grade separation at Idaho St	Western Ave	From 25^{th} to 15^{th} street convert northbound parking lane to travel lane and add 1 southbound travel lane (26.6 miles, 26.6 converted miles, 26.6 new lane miles)
Imperial Highway	Build managed grade separation at Euclid St	Western Ave	From 15^{th} to 1^{st} street (2.0 miles, 4.0 new lane miles) add 1 travel lane to each direction
Imperial Highway	Build managed grade separation at Harbor Blvd	Western Ave	Build managed grade separation at 1^{st} street
Imperial Highway	Build managed grade separation at Brea Blvd	Western Ave	Build managed grade separation at Palos Verdes Dr N
Imperial Highway	Build managed grade separation at State College Blvd	E Western Ave	Build managed grade separation at SR 1
Imperial Highway	Rebuild SR 57 Interchange	Western Ave	Build managed grade separation at Lomita Blvd
Imperial Highway	Build managed grade separation at Associated Road	Western Ave	Build managed grade separation at Sepulveda Blvd
Imperial Highway	Build managed grade separation at Kraemer Blvd	Western Ave	From 228^{th} St to Carson Street (0.9 miles, 0.9 converted miles, 0 new lane miles) convert parking lanes into travel lanes
Imperial Highway	Build managed grade separation at Valencia Ave	Western Ave	Build managed grade separation at 223^{rd} St
Imperial Highway	Build managed grade separation at Birch St	Western Ave	Build managed grade separation at Carson St
Valencia Ave	From Imperial Highway to Carbon Canyon Rd add 1 lane in each direction (1.0 mile, 2.0 lane miles)	Western Ave	From Carson to Del Amo Blvd (1.1 miles, 1.1 converted miles, 0 new lane miles) convert northbound parking lanes into travel lanes
Carbon Canyon Rd	From Valencia Ave to Olinda Dr add 1 lane in each direction (2.8 miles, 5.6 lane miles)	Western Ave	Build managed grade separation at Torrance Blvd
Carbon Canyon Rd	From Olinda Dr to Chino Hills Parkway add 2 lanes in each direction (5.6 miles, 22.4 lane miles)	Western Ave	Build managed grade separation at 190^{th} St
Chino Hills Parkway	From Carbon Canyon Rd to Central Ave add 1 lane in each direction (3.0 miles, 6.0 lane miles)	Western Ave	From 186^{th} to Franklin Ave convert parking lanes to travel lanes 45.4 miles, 90.8 converted miles, 0 new lane miles)
Chino Hills Parkway	Build managed grade separation at Peyton Dr	Western Ave	Rebuild I-405 Interchange
Chino Hills Parkway	Build managed grade separation at Pipeline Ave	Western Ave	Build managed grade separation at 182^{nd} St
Chino Hills Parkway	Rebuild SR 71 Interchange	Western Ave	Build managed grade separation at Artesia Blvd
Chino Hills Parkway	Build managed grade separation at Ramona Ave	Western Ave	Build managed grade separation at 166^{th} St
Chino Hills Parkway	Build managed grade separation at Central Ave	Western Ave	Build managed grade separation at Redondo Beach Blvd
Merrill Ave	From Central Ave to Cypress Ave North add 2 lanes in each direction (0.9 miles, 3.6 lane miles)	Western Ave	Build managed grade separation at Marine Ave
Cypress Ave/Merrill Ave	Cypress Ave North to Archibald Ave add 2 lanes in each direction (5.9 miles, 23.6 lane miles)	Western Ave	Build managed grade separation at Rosecrans Ave
Archibald Ave	From Merrill Ave to Limonite St add 2 lanes in each direction (0.5 miles, 2.0 lane miles)	Western Ave	Build managed grade separation at 135^{th} St
Merrill Ave	Build managed grade separation at Euclid Ave	Western Ave	Build managed grade separation at El Segundo Blvd
Limonite Ave	From Archibald Ave to Wineville Ave add 1 lane in each direction (3.0 miles, 6.0 lane miles)	Western Ave	Rebuild I-105 Interchange
Limonite Ave	Build managed grade separation at Sumner Ave	Western Ave	Rebuild managed grade separation at Imperial Highway
Limonite Ave	Build managed grade separation at Hamner Ave	Western Ave	Build managed grade separation at 108^{th} St
Limonite Ave	Rebuild I-15 Interchange	Western Ave	Build managed grade separation at Century Blvd
Limonite Ave	Build managed grade separation at Wineville Ave	Western Ave	Build managed grade separation at 92^{nd} St

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
Limonite Ave	From Wineville Ave to Homestead St add 2 lanes in each direction (2.7 miles, 10.8 lane miles)	Western Ave	Build managed grade separation at Manchester Ave
Limonite Ave	From Homestead St to Mission Blvd add 1 lane in each direction (5.2 miles, 10.4 lane miles)	Western Ave	Build managed grade separation at Florence Ave
Limonite Ave	Build managed grade separation at Etiwanda Ave	Western Ave	Build managed grade separation at Gage Ave
Limonite Ave	Build managed grade separation at Mission Blvd	Western Ave	Build managed grade separation at 54th St
Riverview Dr	From Mission Blvd to SR 60 add 2 lanes in each direction (0.4 miles, 1.6 lane miles)	Western Ave	Build managed grade separation at 48th St
Riverview Dr	Build Interchange at SR 60	Western Ave	Build managed grade separation at Vernon Ave
Torrance Blvd	Build managed grade separation at SR 1	Western Ave	Build managed grade separation at Martin Luther King Jr Blvd
Torrance Blvd	Build managed grade separation at Prospect Ave	Western Ave	Build managed grade separation at Exposition Blvd
Torrance Blvd	From Catalina Ave to Anza Ave add 1 lane in each direction (1.5 miles, 3.0 lane miles)	Western Ave	Build managed grade separation at Jefferson Blvd
Torrance Blvd	Build managed grade separation at Anza Ave	Western Ave	Build managed grade separation at Adams Blvd
Torrance Blvd	Build managed grade separation at Hawthorne Blvd	Western Ave	Build managed grade separation at Washington Blvd
Hawthorne Blvd	Build managed grade separation at Carson St	Western Ave	Build managed grade separation at Venice Blvd
Carson St	From Hawthorne Blvd to Del Amo Circle Blvd add 1 lane in each direction (0.7 miles, 1.4 lane miles)	Western Ave	Build managed grade separation at W Pico Blvd
Carson St	Build managed grade separation at Madrona Ave	Western Ave	Build managed grade separation at W Olympic Blvd
Carson St	From Madrona Ave to Via Oro Ave convert parking lanes to travel lanes (7.6 miles, 15.2 lane miles)	Western Ave	Build managed grade separation at Oxford Ave
Carson St	Build managed grade separation at Maple Ave	Western Ave	Build managed grade separation at Wilshire Blvd
Carson St	Build managed grade separation at Crenshaw Blvd	Western Ave	Build managed grade separation at 6th St
Carson St	Build managed grade separation at Carbillo Ave	Western Ave	Build managed grade separation at 3rd St
Carson St	Build managed grade separation at Western Ave	Western Ave	Build managed grade separation at Beverly Blvd
Carson St	Build managed grade separation at Normandie Ave	Western Ave	Build managed grade separation at Melrose Ave
Carson St	Build managed grade separation at Vermont Ave	Western Ave	Build managed grade separation at Santa Monica Blvd
Carson St	Rebuild I-110 Interchange	Western Ave	Rebuild US 101 Interchange
Carson St	Build managed grade separation at Figueroa St	Western Ave	Build managed grade separation at Fountain Ave
Carson St	Build managed grade separation at Main St	Western Ave	Build managed grade separation at Sunset Blvd
Carson St	Build managed grade separation at Delores St	Western Ave	Build managed grade separation at Prospect Ave
Carson St	Build managed grade separation at Avalon Blvd	Western Ave	Build managed grade separation at Franklin Ave
Carson St	Rebuild I-405 Interchange	New Alignment	New road connecting Western Ave and Los Feliz Blvd with Buena Vista St and SR 134 (7.6 miles, 45.6 new lane miles)
Carson St	Build managed grade separation at Wilmington Ave	Buena Vista St	Rebuild SR 134 Interchange
Carson St	Build managed grade separation at Santa Fe Ave	Buena Vista St	From SR 134 to San Fernando Blvd convert parking lanes to travel lanes (6.7 miles, 13.4 converted miles, 0 new added lane miles)
Carson St	Build Intersection with I-405 and I-710	Buena Vista St	Build managed grade separation at Alameda Ave
New Alignment	Build 6-lane alignment from I-710 to Bixby Rd at Country Club Rd	Buena Vista St	Build managed grade separation at Olive Ave
Bixby Rd	From Country Club Rd to Atlantic Ave convert parking lanes to travel lanes and add 1 additional lane each direction (0.8 mile, 3.2 lane miles)	Buena Vista St	Build managed grade separation at Magnolia Blvd
Bixby Rd	Build managed grade separation at Long Beach Blvd	Buena Vista St	Build managed grade separation at Burbank St
Bixby Rd	Build managed grade separation at Atlantic Ave	Buena Vista St	Build managed grade separation at Victory Rd
Atlantic Ave	Add one lane each direction between Bixby Rd and Carson St (10.8 lane miles)	Buena Vista St	Build managed grade separation at Empire Ave
Carson St	From Atlantic Ave to Orange Ave, convert parking lanes to travel lanes (1.0 lane mile)	Buena Vista St	Build managed grade separation at San Fernando Blvd
Carson St	Build managed grade separation at Orange Ave	Buena Vista St	From San Fernando Blvd to Glen Oaks Blvd add 1 travel lanes in each direction (0.5 miles, 1.0 miles, 1.0 new added lane miles)
Carson St	From Orange Ave to Cherry Ave add one lane each direction (1.0 lane mile)	Buena Vista St	Rebuild I-5 Intersection
Carson St	Build managed grade separation at Cherry Ave	Buena Vista St	Build managed grade separation at Glen Oaks Blvd
Carson St	Build managed grade separation at Paramount Blvd	Glen Oaks Blvd	From Buena Vista to I-210 convert parking lanes into travel lanes (10.9 miles, 21.8 converted miles, 0 new lane miles)
Carson St	Build managed grade separation at Lakewood Blvd	Glen Oaks Blvd	Build managed grade separation at Sunland Blvd
Carson St	Build managed grade separation at Clark Ave	Glen Oaks Blvd	Build managed grade Separation at Penrose St
Carson St	Build managed grade separation at Mayflower Blvd	Glen Oaks Blvd	Build managed grade separation at Sheldon St
Carson St	Build managed grade separation at Woodruff Ave	Glen Oaks Blvd	Build managed grade separation at Osbourne St
Carson St	Build managed grade separation at Palo Verde Ave	Glen Oaks Blvd	Build managed grade separation at Van Nuys Blvd
Carson St	From Los Coyotes Diagonal to LB Towne Center Dr Add 1 lane in each direction (0.5 mile, 1 lane mile)	Glen Oaks Blvd	Build managed grade separation at Paxton St

Table C5: List of Managed Lane Components

Managed Arterial	Improvement		Managed Arterial	Improvement
Carson St	Rebuild I-605 Interchange		Glen Oaks Blvd	Rebuild SR 118 Interchange
Carson St	Build managed grade separation at Pioneer Blvd		Glen Oaks Blvd	Build managed grade separation at Vaughn St
Lincoln Ave	Build managed grade separation at Norwalk Blvd		Glen Oaks Blvd	Build managed grade separation at Arroyo St
Lincoln Ave	From Pioneer Blvd to Euclid St, add 1 lane each direction (8.1 miles-16.2 lane miles)		Glen Oaks Blvd	Build managed grade separation at Maclay St
Lincoln Ave	Build managed grade separation at Moody St		Glen Oaks Blvd	Build managed grade separation at Hubbard St
Lincoln Ave	Build managed grade separation at Walker St		Glen Oaks Blvd	Build managed grade separation at Sayre St
Lincoln Ave	Build managed grade separation at Valley View St		Glen Oaks Blvd	Build managed grade separation at Polk St
Lincoln Ave	Build managed grade separation at Knott Ave		Glen Oaks Blvd	Build managed grade separation at Tyler St
Lincoln Ave	Build managed grade separation at Western Ave		Glen Oaks Blvd	Build managed grade separation at Bledsoe St
Lincoln Ave	Build managed grade separation at Beach Blvd (dual)		Glen Oaks Blvd	Build managed grade separation at Roxford St
Lincoln Ave	Build managed grade separation at Dade Ave		Glen Oaks Blvd	Rebuild I-210 Interchange
Lincoln Ave	Build managed grade separation at Magnolia St		Beach Blvd	Build managed grade separation at Atlanta Ave
Lincoln Ave	Build managed grade separation at Gilbert St		Beach Blvd	Build managed grade separation at Indianapolis Ave
Lincoln Ave	Build managed grade separation at Brookhurst St		Beach Blvd	Build managed grade separation at Adams Ave
Lincoln Ave	Build managed grade separation at Euclid St		Beach Blvd	Build managed grade separation at Yorktown Ave
Lincoln Ave	Build managed grade separation at Broadway		Beach Blvd	Build managed grade separation at Garfield Ave
Lincoln Ave	From Broadway to Ball Rd add 1 lane in each direction (0.7 mile-1.4 lane miles)		Beach Blvd	Build managed grade separation at Ellis Ave
Lincoln Ave	Build managed grade separation Ball Rd		Beach Blvd	Build managed grade separation at Talbert Ave
Ball Rd	From Euclid St to Hampstead St add 1 lane in each direction (0.5 mile—1.0 lane miles)		Beach Blvd	Build managed grade separation at Slater Ave
Ball Rd	Build managed grade separation at Disneyland Dr		Beach Blvd	Build managed grade separation at Heil Ave
Ball Rd	Rebuild I-5 interchange		Beach Blvd	Build managed grade separation at Edinger Ave
Ball Rd	Build managed grade separation at Harbor Blvd		Beach Blvd	Build managed grade separation at Center Ave
Ball Rd	Build managed grade separation at Anaheim Blvd		Beach Blvd	Build managed grade separation at McFadden Ave
Ball Rd	Build managed grade separation at State College Blvd		Beach Blvd	Build managed grade separation at Bolsa Ave
Ball Rd	From State College Blvd to Sunkist Rd convert parking lanes to through lanes (0.5 mile-1 lane mile)		Beach Blvd	Build managed grade separation at Hazard Ave
Ball Rd	Rebuild SR 57 Interchange		Beach Blvd	Build managed grade separation at Westminster Ave
Taft Ave	Between SR 57 and Tustin St add 1 lane in each direction (2.4 miles-4.8 lane miles)		Beach Blvd	Build managed grade separation at Trask Ave
Taft Ave	Build managed grade separation at N Batavia St		Beach Blvd	Rebuild SR 22 Interchange
Taft Ave	Build managed grade separation at Glassell St		Beach Blvd	Build managed grade separation at Garden Grove Blvd
Taft Ave	Build managed grade separation at Cambridge St		Beach Blvd	Build managed grade separation at Lampson Ave
Taft Ave	Build managed grade separation at Tustin St		Beach Blvd	Build managed grade separation at Chapman Ave
Taft Ave	Build new 6 lane alignment connecting intersection of Taft Ave and Tustin St with Taft Ave and N. Highland St (0.2 miles, 1.2 lane miles)		Beach Blvd	Build managed grade separation at Orangewood Ave
Taft Ave	Rebuild SR 55 Interchange		Beach Blvd	Build managed grade separation at Katelia Ave
Taft Ave	Build managed grade separation at Santiago Blvd		Beach Blvd	Build managed grade separation at Cerritos Ave
Taft Ave	From Santiago Blvd to Center Dr convert parking lanes and add 1 lane in each direction (0.6 miles) (1.2 converted lane miles) (1.2 new lane miles)		Beach Blvd	Build managed grade separation at Ball Rd
Taft Ave	From Center Dr to Cannon St add 2 lane in each direction (1.0 mile-4.0 lane miles)		Beach Blvd	Build managed grade separation at Orange Ave
Cannon St	From Taft Ave to E. Santiago Canyon Rd add 1 lane in each direction (0.4 miles-0.8 lane miles)		Beach Blvd	Build managed grade separation at Crescent Ave
E. Santiago Canyon Dr	From Cannon St to Jamboree Rd add 1 lane in each direction (2.9 miles-5.8 lane miles)		Beach Blvd	Build managed grade separation at La Palma Ave
Jamboree Rd	From E Santiago Canyon Rd NW to E Santiago Canyon Rd SW, add 1 lane in each direction (0.2 miles-0.4 lane miles)		Beach Blvd	Rebuild SR 91 Interchange
E. Santiago Canyon Rd	Build managed grade separation at Chapman Ave		Beach Blvd	Rebuild I-5 Interchange
E. Santiago Canyon Rd	From Chapman Ave to SR 241/SR 261 add 1 lane in each direction (1.0 mile-2 lane mils)		Beach Blvd	Build managed grade separation at Artesia Blvd
E. Santiago Canyon Rd	Rebuild Interchange at SR 241/SR 261		Beach Blvd	Build managed grade separation at Malvern Ave
Warner Ave	Add 1 lane in each direction between SR 1 and Algonquin St (0.9 miles, 1.8 lane miles)		Beach Blvd	Build managed grade separation at Rosecrans Ave
Warner Ave	Build managed grade separation at Graham St		Beach Blvd	Build managed grade separation at Imperial Hwy
Warner Ave	Build managed grade separation at Springdale St		Beach Blvd	Build managed grade separation at Lambert Rd
Warner Ave	Build managed grade separation at Edwards St		Beach Blvd	Build managed grade separation at El Camino Real
Warner Ave	Build managed grade separation at Goldenwest St		Beach Blvd	Build managed grade separation at Whittier Blvd

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
Warner Ave	Build managed grade separation at Gothard St	Beach Blvd	Build managed grade separation at Gregory Lane
Warner Ave	Build managed grade separation at Beach Blvd (dual)	New Alignment	From Gregory Lane And Beach Blvd to Whittier Blvd and Hacienda Ave, (0.4 miles, 2.4 new lane miles)
Warner Ave	Build managed grade separation at Newland St	Hacienda Rd	From Whittier Blvd to Sansinena Ln add 1 lane in each direction (0.4 miles, 0.8 new lane miles)
Warner Ave	Build managed grade separation at Magnolia St	Hacienda Rd	From Sansinena Ln to Glenmark Drive add 2 lanes in each direction (2.6 miles, 5.2 new lane miles)
Warner Ave	Rebuild I-405 Interchange	Hacienda Rd	From Glenmark Drive to Colima Rd add 1 lane in each direction (0.4 miles, 0.8 new lane miles)
Warner Ave	Build managed grade separation at Bushard St	Hacienda Rd	Build managed grade separation at Colima Rd
Warner Ave	Rebuild managed grade Separation at Brookhurst St	Colima Rd	From Hacienda Rd to Azusa Ave add 1 lane in each direction (2.6 miles, 5.2 new lane miles)
Warner Ave	Rebuild managed grade separation at Euclid St	Azusa Ave	Build managed Grade Separation at Colima Rd
Warner Ave	Build managed grade Separation at New Hope St	Azusa Ave	Rebuild SR 60 Interchange
Warner Ave	Build managed grade separation at Harbor Blvd	Azusa Ave	Build managed grade separation at Gale Ave
Warner Ave	Build managed grade separation at Fairview St	Azusa Ave	Build managed grade separation at Arenth Ave
Warner Ave	Build managed grade separation at Raitt St	Azusa Ave	Build managed grade separation at Valley Blvd
Warner Ave	Between Raitt St and Bristol St convert westbound parking lane to travel lane (0.6 mile, 0.6 lane miles)	Azusa Ave	Build managed grade separation at Temple Ave
Warner Ave	Build managed arterial at Bristol St	Azusa Ave	Build managed grade separation at Amar Rd
Warner Ave	Between Bristol St and Grand Ave add one lane in each direction (2.0 miles, 8.0 lane miles)	Azusa Ave	From W Francisquito Ave to E Garvey Ave S Convert southbound parking lane into travel lane (1.4 miles, 1.4 converted lanes)
Warner Ave	Build managed grade separation at Flower St	Azusa Ave	Build managed grade separation at Merced Ave
Warner Ave	Build managed grade separation at Main St	Azusa Ave	Build managed grade separation at Vine Ave
Warner Ave	Build managed grade separation at Grand Ave	Azusa Ave	Build managed grade separation at Cameron Ave
Warner Ave	Convert middle lane to westbound through lane between Grand Ave and Wright St (0.2 miles, 0.4 lane miles)	Azusa Ave	Rebuild I-10 Interchange
Warner Ave	Rebuild SR 55 Interchange	Azusa Ave	Build managed grade separation at Workman Ave
Red Hill Ave	Build managed grade separation at Edinger Ave	Azusa Ave	From Workman Ave to 1st Street convert parking lanes into travel lanes (3.2 miles, 6.4 converted miles)
Edinger Ave	Build interchange at Tustin Ranch Rd	Azusa Ave	Build managed grade separation at Rowland St
Tustin Ranch Rd	Build managed grade separation at Walnut Ave	Azusa Ave	Build managed grade separation at Puente Ave
Tustin Ranch Rd	Rebuild I-5 Interchange	Azusa Ave	Build managed grade separation at Badillo St
Tustin Ranch Rd	Build managed grade separation at El Camino Real	Azusa Ave	Build managed grade separation at San Bernardino Rd
Tustin Ranch Rd	Build managed grade separation at Bryan Ave	Azusa Ave	Build managed grade separation at Cypress St
Tustin Ranch Rd	Build managed grade separation at Irvine Blvd	Azusa Ave	Build managed grade separation at Arrow Highway
Portola Parkway	Build managed grade separation at Jamboree Rd	Azusa Ave	Build managed grade separation at Gladstone St
Portola Parkway	Rebuild SR 261 Interchange	Azusa Ave	Rebuild I-210 Interchange
Portola Parkway	Between Jeffrey Rd and SR 241 add 1 lane in each direction (3.4 miles, 6.8 lane miles)	Azusa Ave	Build managed grade separation at 1st St
Portola Parkway	Rebuild SR 133 Interchange	Azusa Ave	Build managed grade separation at 5th St
Crown Valley Parkway	From SR 1 to Sea Island Dr add 1 lane in each direction (0.4 mile, 0.8 lane mile)	Azusa Ave	Build managed grade separation at Foothill Blvd
Crown Valley Parkway	From Sea Island Dr. to Camino Del Avion (0.4 mile, 0.4 lane miles)	Azusa Ave	Build managed grade separation at W Sierra Madre Ave
Crown Valley Parkway	Build managed grade separation at Camino Del Avion	Fairmont Blvd	Build New Interchange at SR 91
Alicia Parkway	Build managed grade separation at Niguel Rd	Fairmont Blvd	Build managed grade separation at La Palma Ave
Alicia Parkway	Build managed grade separation at Aliso Creek Rd	Fairmont Blvd	Build managed grade separation at Esperanza Rd
Alicia Parkway	Build managed grade separation at Pacific Park Dr	Fairmont Blvd	From Village Center Drive to Singingwood Drive add 1 lane to both directions (5.5 miles, 11.0 new lane miles)
Alicia Parkway	Rebuild SR 73 Interchange	Fairmont Blvd	Build managed grade separation at Yorba Linda Blvd
Alicia Parkway	Build managed grade Separation at Moulton Parkway	Fairmont Blvd	Build managed grade separation at Bastanchury Rd
Alicia Parkway	Build managed grade separation at Paseo De Valencia	Fairmont Blvd	From Singingwood Drive to San Antonio Rd add 2 lanes in both directions (0.9 miles, 3.6 new lane miles)
Alicia Parkway	Rebuild I-5 Interchange	New Alignment	From Fairmont Blvd E of Quarter House Rd to Carbon Canyon Rd E of Beryl St add new roadway (4.0 miles 24.0 lane miles)
Alicia Parkway	Build managed grade separation at Muirlands Blvd	Peyton Dr	From Chino Hills Parkway to Eucalyptus Ave Add 2 lanes in both directions (0.5 miles, 2.0 new lane miles)
Alicia Parkway	Build managed grade separation at Jeronimo Rd	Peyton Dr	Build managed grade separation at Eucalyptus Ave
Alicia Parkway	Build managed grade separation at Trabuco Rd	Peyton Dr	Build managed grade separation at Grand Ave
Alicia Parkway	Build managed grade separation at Marguerite Parkway	Peyton Dr	Build managed grade separation at Chino Ave
Alicia Parkway	Build managed grade separation at Olympiad Rd	Peyton Dr	Rebuild SR 71 Interchange

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
Santa Margarita Parkway	Rebuild SR 241 Interchange	Riverside Dr	From Garey Ave to Baseline Ave add 1 travel lane in each direction (0.2 miles, 0.4 new lane miles)
Santa Margarita Parkway	Build managed grade separation at Avendida De Las Flores	Riverside Dr	Build managed grade separation at Garey Ave
Santa Margarita Parkway	Build managed grade separation at Antonio Parkway	Riverside Dr	Build managed grade separation at Towne Ave
SR 74	Rebuild I-5 Interchange	Towne Ave	Convert parking lanes into travel lanes from Towne Ave to E Baseline Rd (7.2 miles, 14.4 lane miles)
SR 74	From Camino Capistrano to Hunt Club Dr add 1 lane in each direction (1.5 miles, 3.0 lane miles)	Towne Ave	Rebuild SR 60 Interchange
SR 74	From Hunt Club Dr to Reata Rd add 2 lanes in each direction (0.9 miles, 3.6 lane miles)	Towne Ave	Build managed grade separation at Philadelphia St
SR 74	From Reata Rd to Le Harve St (27.3 miles, 54.6 lane miles) add 1 lane in each direction	Towne Ave	Build managed grade separation at Lexington Ave
SR 74	From Le Havre St to Hunco Way, Add 2 lanes in each direction (3.0 miles, 12.0 lane miles)	Towne Ave	Build managed grade separation at Franklin Ave
SR 74	From Hunco Way to I-15 add 1 lane in each direction (1.0 lane mile)	Towne Ave	Build managed grade separation at Philip Blvd
SR 74	Rebuild I-15 Interchange	Towne Ave	Build managed grade separation at E Mission Blvd
SR 74	From Dexter Ave to I-215 Add 1 lane in each direction (20.6 lane miles)	Towne Ave	Build managed grade separation at Holt Ave
SR 74	Build managed grade separation at Perris Blvd	Towne Ave	Rebuild I-10 Interchange
SR 74W	Rebuild I-215 Interchange	Towne Ave	Build managed grade separation at Arrow Highway
SR 74	Build managed grade separation at Case Rd	Towne Ave	Build managed grade separation at Bonita Ave
SR 74	Build managed grade separation at SR 79 S (Dual)	Towne Ave	Build managed grade separation at Foothill Blvd
SR 74	Build managed grade separation at Warren Rd	Towne Ave	Rebuild I-210 Interchange
SR 74	Build managed grade separation at Sanderson Ave	Euclid Ave	From SR 71 to Pomono Rincon Rd Add 1 travel lane in each direction (0.5 mile, 1.0 lane miles)
SR 74	Build managed grade separation at Kirby St	Euclid Ave	From Pomono Rincon Rd to Johnson Ave add 2 travel lanes in each direction (0.5 miles, 1.0 lane miles)
SR 74	Build managed grade separation at Lyon Ave	Euclid Ave	From Johnson Ave to Merion St (add 1 travel lanes in each direction 2.0 miles, 4.0 lane miles)
SR 74	Build managed grade separation at Palm Ave	Euclid Ave	Build managed grade separation at Pine Ave
SR 74	Build managed grade separation at State St	Euclid Ave	Build managed grade separation at Edison Ave
SR 74	Build managed grade separation at San Jacinto St	Euclid Ave	Build managed grade separation at Schaefer Ave
SR 74	Add one lane in each direction from Case Rd to ¼ mile E of San Jacinto Rd (33.8 lane miles)	Euclid Ave	Build managed grade separation at Chino Ave
SR 1, SR 27	Build managed grade separation at SR 107	Euclid Ave	Build managed grade separation at Riverside Dr
SR 1, SR 27	Build managed grade separation at Calle Mayor	Euclid Ave	From Merion St to E H St convert parking lanes to travel lanes (3.5 miles, 7.0 lane miles)
SR 1, SR 27	Add 2 lanes between Ocean Ave and Herondo St (4.5 miles, 9 lane miles)	Euclid Ave	Build managed grade separation at Walnut St
SR 1, SR 27	Build managed grade separation at Palos Verdes Blvd	Euclid Ave	Rebuild SR-60 Interchange
SR 1, SR 27	Build managed grade separation at Torrance Blvd	Euclid Ave	Build managed grade separation at Philadelphia St
SR 1, SR 27	Build managed grade separation at Diamond St	Euclid Ave	Build managed grade separation at Francis St
SR 1, SR 27	Build managed grade separation at Herondo St	Euclid Ave	Build managed grade separation at Philips St
SR 1, SR 27	Build managed grade separation at Artesia Blvd	Euclid Ave	Build managed grade separation at Mission Blvd
SR 1, SR 27	Build managed grade separation at Manhattan Beach Blvd	Euclid Ave	Build managed grade separation at Holt Blvd
SR 1, SR 27	Build managed grade separation at Rosecrans Ave	Euclid Ave	Build managed grade separation at D St
SR 1, SR 27	Build managed grade separation at El Segundo Blvd	Euclid Ave	Build managed grade separation at 4th St
SR 1, SR 27	Build managed grade separation at Grand Ave	Euclid Ave	Build managed grade separation at 6th St
SR 1, SR 27	Build managed grade separation at Imperial Highway	Euclid Ave	Rebuild I-10 Interchange
SR 1, SR 27	Rebuild I-105 Interchange	Euclid Ave	Build managed grade separation at 8th St
SR 1, SR 27	Build managed grade separation at Manchester Ave	Euclid Ave	Build managed grade separation at Arrow Highway
SR 1, SR 27	Build managed grade separation at Jefferson Blvd	Euclid Ave	Build managed grade separation at Foothill Blvd
SR 1, SR 27	From Jefferson Blvd to Fiji Way Add one southbound lane (0.5 mile, 0.5 lane mile)	Euclid Ave	From Foothill Blvd to 24th St add 1 travel lane in each direction (3.0 miles, 6.0 new lane miles)
SR 1, SR 27	Build Interchange at SR 90	Euclid Ave	Build managed grade separation at 13th St
SR 1, SR 27	Build managed grade separation at Washington Blvd	Euclid Ave	Build managed grade separation at 16th St
SR 1, SR 27	From Washington Blvd to I-10 add 1 lane each direction (2.8 miles, 5.6 lane miles)	Euclid Ave	Build managed grade separation at 19th St
SR 1, SR 27	Build managed grade separation at Venice Blvd	Euclid Ave	Rebuild I-210 Interchange
SR 1, SR 27	Build managed grade separation at Rose Ave	El Toro Cut Off Rd	From SR 74 to El Toro Rd at El Toro Rd add 2 lanes in each direction (1.3 miles, 5.2 lane miles)
SR 1, SR 27	Build managed grade separation at Ocean Park Blvd	El Toro Rd	From El Toro Cut Off Rd to Fort Lander Ln add 2 lanes in each

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
			direction (8.8 miles, 35.2 lane miles)
SR 1, SR 27	Build managed grade separation at Pico Blvd	El Toro Rd	From Fort Lander Ln to El Mineral Rd add 2 travel lanes in each direction (0.5 miles, 2.0 new road lanes)
SR 1, SR 27	Rebuild SR 1 at I-10/Olympic Blvd Interchange	Piedras Rd	Build managed grade separation at Santa Rosa Mine Rd
SR 1, SR 27	Build managed grade separation at SR 1 at Channel Blvd and Chautauqua Blvd	Piedras Rd	From El Mineral Rd to Santa Rosa Mine Rd add 2 travel lanes in each direction (0.9 miles, 3.6 new lane miles)
SR 1, SR 27	Build managed grade separation at SR 1/SR 27	Santa Rosa Mine Rd	From Piedras to Lake Matthews Dr add 2 travel lanes in each direction (1.0 miles, 4.0 new lane miles)
SR 1, SR 27	From Temescal Canyon Rd to Avenue St. Louis Add one lane in each direction (14.7 miles, 29.4 lane miles)	Gavilan Rd	From Lake Matthews Dr to Cajalco Rd (2.9 miles, 11.6 new lane miles) add 2 travel lanes in each direction
SR 1, SR 27	Build managed grade separation at Ventura Blvd	Cajalco Rd	From Gavilan Rd to El Sobrante Rd (0.3 miles, 1.2 new lane miles) add 2 travel lanes in each direction
SR 1, SR 27	Rebuild US 101 Interchange	El Sobrante Rd	From Cajalco Rd to Mockingbird Canyon Rd add 2 travel lanes in each direction (1.1 miles, 4.4 new lane miles)
SR 1, SR 27	Build managed grade separation at Burbank Blvd	Mockingbird Canyon Rd	From El Sobrante Rd to Van Buren Blvd add 2 travel lanes in each direction (3.5 miles, 14.0 new lane miles)
SR 1, SR 27	Build managed grade separation at Oxnard St	Van Buren Blvd	From Mockingbird Canyon Rd to Rudcill St add 1 travel lane in each direction (2.6 miles, 5.2 new lane miles)
SR 1, SR 27	Build managed grade separation at Victory Blvd	Van Buren Blvd	Build managed grade separation at Victoria Ave
SR 1, SR 27	Build managed grade separation at Vanowen St	Van Buren Blvd	Build managed grade separation at Indiana Ave
SR 1, SR 27	Build managed grade separation at Sherman Way	Van Buren Blvd	Rebuild SR 91 Interchange
SR 1, SR 27	Build managed grade separation at Saticoy St	Van Buren Blvd	Build managed grade separation at Magnolia Ave
SR 1, SR 27	Build managed grade separation at Roscoe Blvd	Van Buren Blvd	From Garfield St to Cypress Ave add 1 travel lane in each direction (1.8 miles, 3.6 new lane miles)
SR 1, SR 27	From Parthenia St to Prarie St convert Parking lanes to travel lanes (0.8 miles, 1.6 lane miles)	Van Buren Blvd	Build managed grade separation at California Ave
SR 1, SR 27	Build managed grade separation at Plummer St	Van Buren Blvd	Build managed grade separation at Jackson St
SR 1, SR 27	From Marilla St to SR 118 convert parking lanes to travel lanes (2.1 miles, 4.2 lane miles)	Van Buren Blvd	Build managed grade separation at Arlington Ave
SR 1, SR 27	Build managed grade separation at Larson St	Van Buren Blvd	From Jurupa Ave to Jurupa Rd add 1 lane in each direction (3.1 miles, 6.2 lane miles)
SR 1, SR 27	Build managed grade separation at Devonshire St	Van Buren Blvd	Build managed grade separation at Jurupa Rd
SR 23	SR 1 to Triunfo Canyon Rd add 2 lanes in each direction (11.0 miles, 22 lane miles)	Jurupa Rd	From Van Buren Blvd to Valley Way add 2 lanes in each direction (2.7 miles, 10.8 lane miles)
SR 23	Build managed grade separation at Agoura Rd	Jurupa Rd	Build managed grade separation at Pedley Rd
SR 23	Rebuild Interchange at US 101	Jurupa Rd	Build managed grade separation at Camino Real
Westlake Blvd	Build managed grade separation at Thousand Oaks Rd	Valley Way	From Jurupa Rd to Mission Blvd add 2 lanes in each direction (0.4 miles, 1.6 lane miles)
Westlake Blvd	From Hillcrest Dr to Eagle Claw Ave add one lane in each direction (3.6 miles, 7.2 lane miles)	Valley Way	Build managed grade separation at Mission Blvd
Westlake Blvd	From Eagle Claw Ave to 0.1 mi W of Oak Valley Lane add 2 lanes in each direction (0.3 mile, 1.2 lane mile)	Armstrong Rd	From Jurupa Rd to Sierra Ave add 1 lane in each direction (1.0 miles, 2.0 new lane miles)
New Alignment	From Westlake Blvd 0.1 mile west of Oak Valley Lane to Wood Ranch Parkway at Long Canyon Rd (2.0 miles, 8.0 lane miles)	Sierra Ave	From Armstrong Rd to Santa Ana Ave add 1 lane in each direction (2.6 miles, 5.2 lane miles)
Wood Ranch Parkway	From Long Canyon Rd to Madera Rd add 1 lane in each direction (2.0 miles, 4 lane miles)	Sierra Ave	Build managed grade separation at Santa Ana Ave
Madera Rd	From Wood Ranch Parkway to MaCaw Lane convert southwestbound parking lane to travel lane (1.1 miles, 1.1 lane miles)	Sierra Ave	Build managed grade separation at Slover Ave
Madera Rd	Managed grade separation at Tierra Rejada Rd	Sierra Ave	Rebuild I-10 Interchange
Madera Rd	Managed grade separation at Easy St	Sierra Ave	Build managed grade separation at Valley Blvd
La Cienega Blvd	Rebuild I-405 Interchange Reconstruction	Sierra Ave	Build managed grade separation at San Bernardino Ave
La Cienega Blvd	From I-405 to Glenway Dr convert southbound parking lane to travel lane (0.7 miles, 0.7 lane miles)	Sierra Ave	From San Bernardino Ave to Baseline Ave, convert parking lanes to travel lanes (3.0 miles, 3.0 lane miles)
La Cienega Blvd	Build managed grade separation at Centinela Ave	Sierra Ave	Build managed grade separation at Randall Ave
La Cienega Blvd	Build managed grade separation at La Tijera Blvd	Sierra Ave	Build managed grade separation at Merrill Ave
La Cienega Blvd	Build managed grade separation at Rodeo Rd	Sierra Ave	Build managed grade separation at Arrow Blvd
La Cienega Blvd	Build managed grade separation at Jefferson Blvd	Sierra Ave	Build managed grade separation at Foothill Blvd
La Cienega Blvd	Build managed grade separation at Washington Blvd	Sierra Ave	Build managed grade separation at Miller Ave
La Cienega Blvd	Build managed grade separation at Venice Blvd	Sierra Ave	Build managed grade separation at Baseline Rd
La Cienega Blvd	Rebuild I-10 interchange	Sierra Ave	From Summit Ave to I-15 (2.0 miles, 8.0 new lane miles) add 2 travel lanes in each direction
La Cienega Blvd	Build managed grade separation at Cadillac Ave	Sierra Ave	Build managed grade separation at Highland Ave
La Cienega Blvd	Build managed grade separation at at Pico Blvd	Sierra Ave	Rebuild I-210 Interchange
La Cienega Blvd	Build managed grade separation at Olympic Blvd	Sierra Ave	Build managed grade separation at Sierra Lakes Parkway
La Cienega Blvd	Build managed grade separation at Wilshire Blvd	SR 79	Rebuild I-15 Interchange

Table C5: List of Managed Lane Components

Managed Arterial	Improvement	Managed Arterial	Improvement
La Cienega Blvd	Build managed grade separation at San Vicente Blvd	SR 79	Build managed grade separation at Margarita Rd
La Cienega Blvd	Build managed grade separation at 3rd St	SR 79	Build managed grade separation at Murrieta Hot Springs Rd
La Cienega Blvd	Build managed grade separation at Beverly Blvd	SR 79	From Hunter Rd to Pourroy Rd add 1 travel lane in each direction (3.9 miles, 7.8 new lane miles)
La Cienega Blvd	Build managed grade separation at Melrose Ave	SR 79	Build managed grade separation at Leon Rd
La Cienega Blvd	From Beverly Blvd to Santa Monica Blvd convert parking lanes to travel lanes (0.2 miles, 0.4 lane miles)	SR 79	From Pourroy Rd to SR 74 add 2 travel lanes in each direction (9.3 miles, 37.2 new lane miles)
La Cienega Blvd	Build managed grade separation at Santa Monica Blvd	SR 79	Build managed grade separation at Scott Rd
Sunset Blvd	From La Cienega Blvd to Marmont Lane add 1 lane in each direction (0.5 mile, 1 lane mile)	SR 79	Build managed grade separation at Domenigoni Parkway
Laurel Canyon Blvd	From Sunset Blvd to Mt. Olympus Dr add 1 lane in each direction (0.4 mile, 0.8 lane miles)	SR 79	Build managed grade separation at Simpson Rd
Laurel Canyon Blvd	From Mt. Olympus Dr to Mulholland Dr add 2 lanes in each direction (1.8 miles, 7.2 lane miles)	Juniper Springs Rd Extension	From SR 74 to Juniper Springs Curve build new roadway (2.5 miles, 15.0 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Mulholland Dr	Juniper Springs Rd	From Juniper Springs Curve to Juniper Flats Rd Add 2 travel lanes in each direction (3.5 miles, 14.0 new lane miles)
Laurel Canyon Blvd	From Mullholland Dr to Maxwellton Rd add 1 lane in each direction (1.9 miles, 3.8 lane miles)	Juniper Flats Rd	From Juniper Spring Rd to Contour Ave add 2 travel lanes in each direction (2.8 miles, 11.2 new lane miles)
Laurel Canyon Blvd	Build managed grade separation at Ventura Blvd	Contour Ave	From Juniper Flats Rd to Hansen Ave (1.1 miles, 4.4 new lane miles) add 2 travel lanes in each direction
Laurel Canyon Blvd	From Maxwellton Rd to Webb Ave convert parking lanes to travel lanes (7.7 miles, 15.4 lane miles)	Hansen Ave	From Contour Ave to Ramona Expressway add 2 travel lanes in each direction (2.1 miles, 4.2 new lane miles)
Laurel Canyon Blvd	Build managed grade separation at Moorpark St	Hansen Ave	Build managed grade separation at Ramona Expressway
Laurel Canyon Blvd	Rebuild US 101 interchange	Davis Rd	From Ramona Expressway to South of Alessandro Blvd add 2 travel lanes in each direction (5.9 miles, 23.6 new lane miles)
Laurel Canyon Blvd	Build managed grade separation at Riverside Dr	Theodore St	From south of Alessandro Blvd to Ironwood Ave add 2 travel lanes in each direction (2.0 miles, 4.0 new lane miles)
Laurel Canyon Blvd	Build managed grade separation at Magnolia Blvd	Ironwood Ave	From Theodore St to Redlands Blvd add 2 lanes in each direction (1.0 mile, 4.0 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Chandler Blvd	Redlands Blvd	From Ironwood Ave to San Timoteo Canyon Rd Add 2 lanes in each direction) 3.3 miles, 13.2 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Burbank Blvd	San Timoteo Canyon Rd	From Redlands Blvd to Alessandro Rd add 2 lanes in each direction (2.2 miles, 8.8 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Oxnard St	Alessandro Rd	From San Timoteo Canyon Rd to Crescent Ave add 2 lanes in each direction (1.6 miles, 6.4 lane miles)
Laurel Canyon Blvd	Rebuild SR 170 interchange	Crescent Ave	From Alessandro Rd to San Jacinto Rd add 2 lanes in each direction (.01 miles, .04 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Victory Blvd	San Jacinto St	From Crescent Ave to Highland Ave add 2 lanes in each direction (0.2 miles, 0.8 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Vanowen St	Highland Ave	From San Jacinto St to San Mateo St add 2 lanes in each direction (0.2 miles, 0.8 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Sherman Way	San Mateo St	From Highland Ave to Clifton Ave add 1 lane in each direction, convert parking lanes to travel lanes (0.4 miles, 1.6 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Saticoy St	San Mateo St	From Clifton Ave to I-10/I-210 convert parking lanes to travel lanes (2.1 miles, 4.2 lane miles)
Laurel Canyon Blvd	Build managed grade separation at Strathern St	San Mateo St	Build managed grade separation at Brookside Ave
Laurel Canyon Blvd	Build managed grade separation at Roscoe Blvd	Tennessee St	Build managed grade separation at State St
Laurel Canyon Blvd	From Webb Ave to Sheldon St add 1 lane in each direction (0.6 mile, 1.2 lane miles)	Tennessee St	Build managed grade separation at Redlands Blvd
Laurel Canyon Blvd	Rebuild I-5 Interchange	Tennessee St	Build managed grade separation at Colton St
Sheldon St	From Laurel Canyon Rd to San Fernando Rd add 1 lane in each direction (0.8 mile, 1.6 lane miles)		

Table C6: Managed Arterial Revenue and Cost Calculations

Years	Inflation	Total Gross Revenue	Total Net Revenue		Years	Lane Additions	Grade Separations	New Alignments	Total
2020		1559379972	1325472976		2015	458080000	935,280,000	81040000	1474400000
2021	1.03	1604601991	1363911693		2016	471364320	962403120	83390160	1517157600
2022	1.03	1651135449	1403465132		2017	485033885.3	990312810.5	85808474.64	1561155170
2023	1.03	1699018377	1444165620		2018	499099868	1019031882	88296920.4	1606428670
2024	1.03	1748289910	1486046423		2019	513573764.1	1048583807	90857531.1	1653015102
2025	1.03	1798990317	1529141770		2020	528467403.3	1078992737	93492399.5	1700952540
2026	1.03	1851161036	1573486881		2021	543792958	1110283526	96203679.08	1750280163
2027	1.03	1904844707	1619118001		2022	559562953.8	1142481749	98993585.78	1801038288
2028	1.03	1960085203	1666072423		2023	575790279.4	1175613719	101864399.8	1853268398
2029	1.03	2016927674	1714388523		2024	592488197.5	1209706517	104818467.4	1907013182
2030	1.03	2075418576	1764105790		2025	609670355.3	1244788006	107858202.9	1962316564
2031	1.03	2135605715	1815264858		2026	627350795.6	1280886858	110986090.8	2019223745
2032	1.03	2197538281	1867907539		2027	645543968.6	1318032577	114204687.4	2077781233
2033	1.03	2261266891	1922076857		2028	664264743.7	1356255522	117516623.4	2138036889
2034	1.03	2326843631	1977817086		2029	683528421.3	1395586932	120924605.4	2200039959
2035	1.03	2394322096	2035173782		2030	703350745.5	1436058953	124431419	2263841118
2036	1.03	2463757437	2094193821		2031	723747917.1	1477704663	128039930.2	2329492510
2037	1.03	2535206403	2154925442		2032	744736606.7	1520558098	131753088.1	2397047793
2038	1.03	2608727388	2217418280		2033	766333968.3	1564654283	135573927.7	2466562179
2039	1.03	2684380483	2281723410		2034	788557653.4	1610029257	139505571.6	2538092482
2040	1.03	2762227517	2347893389		2035	811425825.3	1656720105	143551233.2	2611697164
2041	1.03	2842332115	2415982297		2036	834957174.3	1704764989	147714218.9	2687436382
2042	1.03	2924759746	2486045784		2037	859170932.3	1754203173	151997931.3	2765372037
2043	1.03	3009577779	2558141112		2038	884086889.4	1805075065	156405871.3	2845567826
2044	1.03	3096855534	2632327204		2039	909725409.2	1857422242	160941641.5	2928089293
2045	1.03	3186664345	2708664693			16483705035	33,655,430,591	2916170660	53055306287
2046	1.03	3279077611	2787215969						
2047	1.03	3374170861	2868045232		Category	Total Costs in FY 2015 Dollars*			
2048	1.03	3472021816	2951218544		Lane Additions	11,452,000,000			
2049	1.03	3572710449	3036803882		Grade Separations	23,382,000,000			
2050	1.03	3676319052	3124871194		New Alignments	2,026,000,000			
2051	1.03	3782932304	3215492459			36,860,000,000			
2052	1.03	3892637341	3308741740						
2053	1.03	4005523824	3404695251						
2054	1.03	4121684015	3503431413						
2055	1.03	4241212852	3605030924						
2056	1.03	4364208024	3709576821						
2057	1.03	4490770057	3817154548						
2058	1.03	4621002389	3927852030						
2059	1.03	4755011458	4041759739						
		1.14949E+11	97706820531						

Note: These are the numbers in 2015 while the ones above are in nominal dollars.

Table C7: Managed Arterial Usage and Revenue

	Traffic	Percent Using	Rate	Number	Total
Peak	43800	0.5	0.35	559	4284735
Shoulder	21500	0.35	0.25	559	1051618.75
Off	21500	0.2	0.15	559	360555
					5696908.75
Weekend	52560	0.2	0.2	559	1175241.6
					6872150.35
Weekdays	250	1424227188			
Weekends/Holidays	115	135152784			
Total		1559379972			

Appendix D: New Expressway/Tunnel Details

We presented an overview of the tunnel calculations in the main body of the report. This first part of this appendix has more detail on the modeling and model components.

The second part of this appendix provides the full details for the revenue and costs of each of the new expressway/tunnel projects. Tables D7 through D13 show the revenue for the I-710T, GPT, DBT, HDC, ICE and XMT projects. Table D14 lists the costs for each of the individual projects and a composite total of the projects together. Revenue and costs were calculated in a similar method to the express lane network. Those calculations are detailed in Appendix B.

A. Method

We used the SCAG demographic forecasts extrapolated to 2035 and then ran traffic assignments on the two combinations of projects using the optimal toll and facility size as determined in the original assessments. This appendix documents the results of these assignments. To adjust SCAG's data to the years of our plan, we extrapolated 2040 projections from 2035 data.

This assessment uses TransCAD© multi-class traffic assignment as its underlying methodology.[185] Working with the region's MPO, the Southern California Association of Governments (SCAG), we first obtained the 2035 traffic model, the 2035 road network (with planned routes) and 2035 and 2003 origin-destination matrices for six vehicle classes. We concentrated on the PM peak hours (4–7 PM); time constraints did not permit separate assessment of the AM peak or off-peak, so results are expanded to account for those hours.

The SCAG modeling system calculates road capacities and other necessary statistics internally. However, since some internal calculations are not available to us, we approximated them using estimated capacity parameters from the literature. Specifically, we used a modified volume-capacity decay function, using a variant of the familiar (Bureau of Public Roads) BPR curve, rather than SCAG's Acelik function. Our results compare reasonably well, but not exactly, with 2035 traffic flows in the SCAG model. At the regional level, they are quite close, but for individual links they vary, sometimes significantly. Model output includes link volumes, vehicle-miles and vehicle-hours of travel for each link, speed, V/C ratio and other statistics.

Of the seven projects, only the I-710 Tolled Tunnel (I-710T) and the High Desert Corridor (HDC) were included in the SCAG 2035 network, so we treated these facilities differently. For the I-710T, we assigned a fixed toll to key links and for the HDC, we used the proposed five toll gantry segments as key links and assigned a per-mile toll based on highway length in the vicinity of each toll gantry. For the other five projects we assigned per-mile tolls to the main facility links, excluding ramps. As in the original assessments, we ran PM traffic assignments to determine the volume of traffic, the Vehicle-Miles Traveled (VMT) and Vehicle-Hours Traveled (VHT), and the toll revenues generated. We allowed only single-occupant driver, shared ride 2, shared ride 3, and light trucks to use most facilities; medium and heavy trucks were “tolled off” (except the HDC) using an excessive toll of $1,000/mile. We employed “user equilibrium” principles for all assignments. We then expanded the PM peak results to daily estimates, assuming that the AM peak is similar to the PM and that the remaining off-peak traffic is about 46% of the AM and PM peaks; this leads to a PM-to-Day expansion factor of 2.92.

We are concerned with the combined effects of the optimal tolls as previously determined (and noted in the table above) for the year 2035 only. To complete the analysis, however, we did need to run several other toll assignments. These include a $0 (no toll) for 2035, a $1,000 toll (which effectively provided data on network traffic without the facilities being built) for 2035,[186] $0 toll for 2003 (the base year) and a derived optimal toll for 2003. For vehicle values of time, we used $25/hour (current $) for drive-alone cars (DA), $35/hour for carpools with two occupants (SR2), $45/hour for carpools with three occupants (SR3), $45/hour for light trucks (LT), $50/hour for medium trucks (MT) and $75/hour for heavy trucks (HT); these are generally consistent with the values of time used in other studies, which account for both saved time and improved reliability.[187]

User benefits are computed using $25/hour as the average vehicle value of time saved, $0.20 per vehicle-mile as the average operating cost, and $5.8 million per life saved as the value of a fatality avoided. Total user benefits are computed on the basis of 40 years.[188] Inflation is assumed at 2.9% per year, and the discount rate (value of money) is assumed to be 5% per year.

B. Findings

The following tables summarize major findings from our analysis.

Combo 3: I-710T, GPT and DBT

Table D1 summarizes the results of the three facilities separately and in combination.

Table D1: Summary Results for Combo 3

Item	Totals Separately	Totals in Combination	Separate to Combo, % Change
2035 Avg Daily Traffic with Toll, New Facilities	71,271	83,745	17.5
2035 Avg PM Level of Service (LOS)	C	E	
2035 Avg Percent Capacity Used, PM	53	89	
2035 Daily VMT, New Facilities	2,382,388	2,683,245	12.6
2035 Daily VHT, New Facilities	68,977	70,101	1.6
Daily Regional VMT Saved	-1,108,366	-1,079,505	-2.6
Daily Regional VHT Saved	-242,024	-298,410	23.3

There is a significant cumulative effect for these three facilities when operated in combination rather than separately. On average, traffic on the new facilities increases more than 17%, which increases toll revenues almost 11%. Both VMT and VHT on the new facilities also increase. However, the region-wide savings in VMT is not as great in combination, as people drive farther to take advantage of the new facilities, but region-wide savings in VHT increases over 23%. Since most of the user benefits derive from travel time-savings, user benefits increase over 22%. This increase in facility use, however, comes with a downside. As more people are using the new facilities, the level of service (LOS) decreases, in this case significantly, dropping from LOS C to E. The percent of highway capacity used increases from 53% to 89%, which suggests that either additional capacity or higher tolls will be needed in future years to provide users a smoothly flowing facility in exchange for their toll dollar.

In particular, the I-710 tunnel experiences a significant growth in traffic when operated in combination, increasing from 118,000 to 169,000 daily. This increases the percent of capacity used in the PM peak from 75% to 106% and drops the LOS from D to F. Perhaps this is because we used an optimal toll ($2.00 in 2015 dollars) well below the maximum revenue toll, which was in the $3.00 range. We model tolls as increasing with inflation, but this increase might not be large enough to ensure LOS D or better.

Combo 7

Our research of Southern California's mobility problems led us to study seven potential expressways/tunnels. However, one of the projects—the Santa Ana Connector extending SR 57 southward from I-5 to I-405—had a low cost-benefit relationship. As a result, we eliminated this project from our plan. In this section, we included the modeling for the seven projects to illustrate how the projects work individually and as part of a network. The following table summarizes the results of the three facilities separately and in combination.

Table D2: Summary Results for Combo 7

Item	Totals Separately	Totals in Combination	Separate to Combo, % Change
2035 Avg Daily Traffic with Toll, New Facilities	57,063	58,452	2.4
2035 Avg PM Level of Service (LOS)	C	D	
2035 Avg Percent Capacity Used, PM	50	72	
2035 Daily VMT, at Toll on New Facilities	5,762,106	5,826,623	1.1
2035 Daily VHT, at Toll on New Facilities	139,569	134,204	-3.8
Daily Regional VMT Saved	-1,445,472	-1,215,552	-15.9
Daily Regional VHT Saved	-472,652	-518,001	9.6

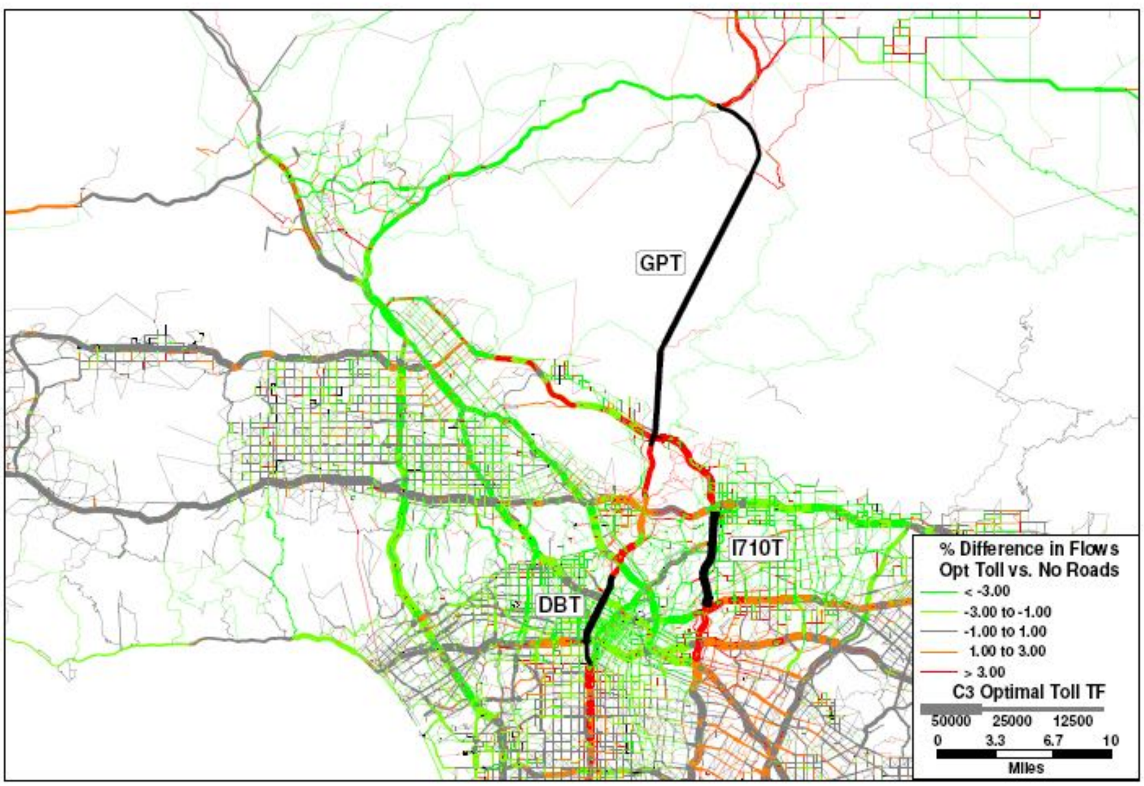
The cumulative effect of the combination of seven projects is not as significant as the combination of three. Facility use when operated in combination is comparable to that when operated individually. Traffic is up slightly (2.4%), VMT is up slightly (1.1%) and VHT is down slightly (3.8%). Toll revenues are also up slightly (1.0%) while user benefits are up a more significant 8.8%. The higher increase in user benefits is caused by the increase in region-wide VHT savings of 9.6%; however, region-wide VMT savings is down almost 16% as drivers increase their travel to take advantage of the new facilities. The lower increase in average facility use, as compared to the three-project combination, means that there is less degradation in LOS. Percent capacity used in the PM peak increases from 50% to 72% and LOS declines from C to D. This indicates that capacity additions or toll increases will be needed in the out years to maintain good travel speed across the tolled facilities, but on average, such additions/increases will be needed later than for the combination of three.

As in the combination of three, the I-710 tunnel experiences the largest increase in traffic and hence the most significant decline in LOS, going from D to F when operated in combination. As noted above, this could be because of the use of an optimal toll well below the maximum revenue toll, which, if so, suggests that toll rates could be increased on this facility in the out years to divert some traffic and improve LOS levels.

C. Impacts on the Network

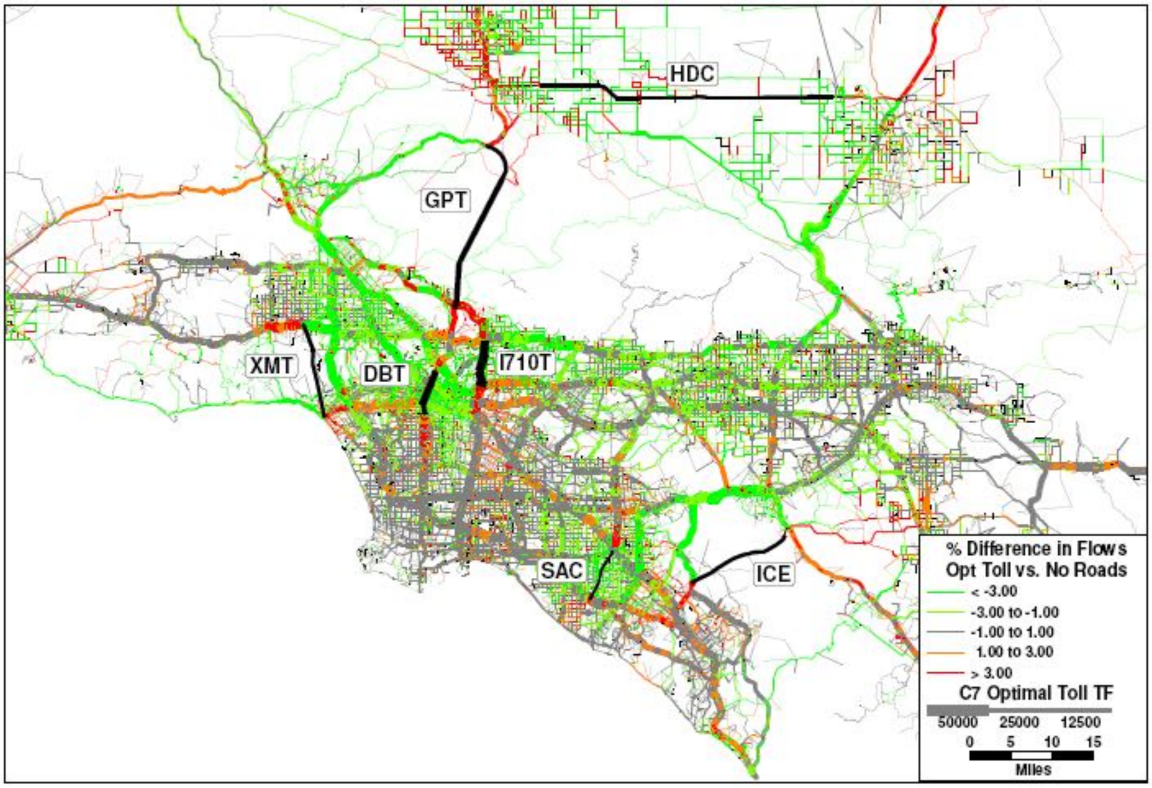
When new facilities are introduced into the network, there are diversions from existing routes to the new facility to take advantage of the increased accessibility offered by the new project. Generally, a new road will reduce traffic on parallel routes, and increase traffic on feeder (end point) and crossing (perpendicular) routes. The maps below show changes in traffic on existing routes if the combinations of facilities were built and the stated tolls levied. Colors represent the traffic gains and losses; "greens" lose 1% or more of traffic flow, while "reds" gain 1% or more. (High percent changes far from the facilities are likely caused by anomalies in TransCAD©, including convergence and OD patterns and are generally ignored.[189]) Most roads, however, see only minor traffic shifts in the -1.0% to 1.0% range and are shaded in gray.

Figure D1: Combo 3 Impacts on the Regional Network



In the combination of three projects, as expected, the key feeder routes along the DBT-GPT axis (SR-14 in the far north, the Glendale Freeway in the center, and I-110 in the south) and along I710T (I-210 in the north and I-710 in the south) see the largest increases in traffic. Alternate routes (SR-14 to the northwest of the three facilities, I-405, US-101 and I-5 to the west, the I-10/I-5 "loop" in the midst of the three, and I-210 to the east) see the largest decreases. Elsewhere in the general area are slight increases and decreases as people alter their driving patterns to take advantage of these facilities themselves or the new alternate pathways opened up by the shifts in traffic.

Figure D2: Combo 7 Impacts on the Regional Network



The above map shows all seven projects. The impacts in and around the DBT, GPT and I-710T are similar to the impacts of the combination of just the three, noted above. The XMT adds some traffic to US-101 west of the junction and diverts some traffic east of the junction, and has a similar but reverse effect at its southern junction with I-10; traffic to the east increases while traffic to the west decreases. The feeder routes north and south of the SAC see increases while most other roads in the vicinity see decreases. The ICE carries a lot of the traffic originally on I-15, SR-91, and I-5 north of the facility, but causes traffic increases south of its junctions with I-5 in the west and I-15 in the east. And finally, the HDC shifts traffic from parallel routes, improving their flow, but adds some traffic at the feeder routes.

Table D3: Vehicle Classifications, Values of Time, and Toll Strategies

	Vehicle Class					
	Drive Alone	Shared Ride 2	Shared Ride 3	Light Trucks	Medium Trucks	Heavy Trucks
Value of Time/ hour	$25.00	$35.00	$45.00	$45.00	$50.00	$75.00
Value of Time/ minute	$0.42	$0.58	$0.75	$0.75	$0.83	$1.25
Average Toll						
I-710 Tunnel - $2.00 Flat	$2.00	$2.00	$2.00	$2.00	$1000.00	$1000.00
GPT - $0.90/mile	$0.90	$0.90	$0.90	$0.90	$1000.00	$1000.00
DBT - $1.00/mile	$1.00	$1.00	$1.00	$1.00	$1000.00	$1000.00
HDC - $0.40/mile	$0.40	$0.40	$0.40	$0.40	$0.40	$0.40
ICE - $0.70/mile	$0.70	$0.70	$0.70	$0.70	$1000.00	$1000.00
XMT - $0.60/mile	$0.60	$0.60	$0.60	$0.60	$1000.00	$1000.00
SAC - $0.40/mile	$0.40	$0.40	$0.40	$0.40	$1000.00	$1000.00

- **Network description**: The above table shows the data used in the SCAG Regional Planning Model, based on the following files, provided by SCAG:
  - Model input and output files from *08R35f_PL_run4*, to include the 2035 network links file with LRTP projects coded (*08r35pl_links*)
  - The 2035 Origin-Destination matrix file for six modes (*DA, SR2, SR3, Lt Trucks, Med Trucks, Heavy Trucks)* for the PM period only (*PM OD, 2035*).
  - The 2035 PM traffic assignment flows, by mode (*08r35pl_links+MMA_LinkFlow*)
  - The TAZ data layer
  - SCAG Planning Model files (*scagnew_ui*)
  - The User's Guide for the SCAG Regional Planning Model, containing assignment method (user equilibrium), delay functions used (Akcelik), input parameters, etc.

- **Delay function modification:** We used a modified Bureau of Public Roads (BPR) function rather than the SCAG Acelik function (which was not available to us).
  - We ran an initial traffic assignment using the BPR coefficients generated in the Initialization Step of the SCAG Model. These coefficients were separated by functional class.
  - We calculated the differences in flows, VMT and VHT between the initial run and the traffic assignment results provided by SCAG. While our results were close to SCAG's in flows and VMT, our model predicted a higher VHT than the SCAG model.
  - We determined the issue with our model was on the expressways and the arterials; the other classes were within an acceptable range.
  - We then modified the alpha coefficients to "speed up" travel and re-ran the assignment.
  - The differences on the arterials were closer, but not on the expressways. So we made one more change, which brought VHT on the expressways in line.
  - The resulting coefficients by functional class are noted below.

The following tables and values use SCAG model data and explain the missing parameters.

Table D4: Modifications to SCAG BPR Coefficients

Facility Type	BPR Alpha	BPR Beta	Modified BPR Alpha Beta	
1 – Freeways (All)	1.1600	4.3300	0.4633	0.4040
2 – HOV (All)	1.1600	4.3300		
3 – Expressway/Parkway (All)	1.0718	1.6000		
4 – Principal Arterial				
40 – Undivided	1.0718	1.6000	0.6786	
41 – Divided	1.0718	1.6000	0.5667	
42 – Continuous Left Turn	1.0718	1.6000	0.5484	
5 – Minor Arterial				
50 – Undivided	1.0718	1.6000	0.5222	
51 – Divided	1.0718	1.6000	0.5137	
52 – Continuous Left Turn	1.0718	1.6000	0.6145	
6 – Major Collector (All)	1.0718	1.6000		
7 – Minor Collector (All)	1.0718	1.6000		
8 – Ramps (All)	1.1600	4.3300		
9 – Trucks (All)	1.1600	4.3300		
10– Centroid connector	0.0100	4.0000		

- **Miscellaneous parameters:**
  - Future year: **2035**
  - Operating cost: **$0.20/mile** (for all traffic)
  - Accident cost: **$ 5.8** million/fatality
  - Accident rate: **1.15** fatalities/100 million vehicle-miles

Table D5: Project Data for Combo 3 Projects, Considered in Combination

Projects by Themselves In Combo 3	I-710T	HDC	GPT	ICE	XMT	SAC	DBT	Combo 3
2035 Daily Traffic at Toll	170,941		57,139				96,772	83,745
2035 PM Level of Service	F		B				D	E
2035 Percent Capacity Used, PM	107		48				81	89
2035 Daily VMT at Toll	970,451		1,208,791				504,002	2,683,245
2035 Daily VHT at Toll	31,293		26,516				12,292	70,101
Daily VMT Saved	NA		NA				NA	-1,079,505
Daily VHT Saved	NA		NA				NA	-298,410

Note: Data based on traffic assignments in Combo 3 assessment.

Table D6: Project Data for Combo 7 Projects, Considered in Combination

Projects by Themselves In Combo 7	I-710T	HDC	GPT	ICE	XMT	SAC	DBT	Combo 7
2035 Daily Traffic at Toll	169,100	51,509	54,120	46,008	47,596	31,973	94,366	58,452
2035 PM Level of Service	F	B	B	C	B	B	D	D
2035 Percent Capacity Used, PM	106	43	45	58	40	40	79	72
2035 Daily VMT at Toll	959,999	1,889,809	1,144,934	570,248	538,689	231,470	491,474	5,826,623
2035 Daily VHT at Toll	30,586	36,617	24,856	12,147	12,538	5,641	11,819	134,204
Daily VMT Saved	NA	NA	NA	NA	NA	NA	NA	-1,215,552
Daily VHT Saved	NA	NA	NA	NA	NA	NA	NA	-518,001

Note: Data based on traffic assignments in Combo 7 assessment.

Table D7: Project Data for All Projects, Considered Individually

Projects by Themselves Alone	I-710T*	HDC*	GPT*	ICE*	XMT*	SAC*	DBT*	C7 Totals**	C3 Totals**
2035 Daily Traffic at Toll	118,665	53,985	53,137	48,200	51,262	34,023	93,271	57,063	71,271
2035 PM Level of Service	D	B	B	C	B	B	D	C	C
2035 Percent Capacity Used, PM	75	45	44	60	39	43	78	50	53
2035 Daily VMT at Toll	772,653	1,955,806	1,123,947	597,412	580,184	246,316	485,788	5,762,106	2,382,388
2035 Daily VHT at Toll	33,061	38,165	24,347	12,864	13,548	6,016	11,569	139,569	68,977
Daily VMT Saved	34,368	-52,997	-1,143,710	-228,022	-41,230	-14,857	975	-1,445,472	-1,108,366
Daily VHT Saved	-33,944	-98,075	-159,699	-66,361	-62,040	-4,151	-48,382	-472,652	-242,024

* Based on traffic assignments in original assessments.

** Calculated (sums or weighted averages) from project data in table.

Note: As we mentioned previously, due to the poor performance (high cost, low toll revenue, limited congestion relief) in our traffic demand model of the proposed SR 57 extension southward from I-5 to I-405 (abbreviated as SAC), we dropped the project from our final report. This increased the effects of the combination of three projects significantly. Without SAC, the new Combo 6 performs almost as well as Combo 3 (costs, toll revenue, congestion relief).

Table D8: I-710 Expressway Extension/Tunnel												
Year	Toll Rate	Infla-tion	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue	NPV	Net Gross
2020	2.31	1.03	97525.79	225284.58	365.25	82285192.64	69942413.75	1.0000	69942413.75	225284.58	82285192.64
2021	2.38	1.03	98501.05	234136.01	365.25	85518177.86	72690451.18	0.9524	69229001.13	227537.43	83108044.57
2022	2.45	1.03	99486.06	243335.21	365.25	88878187.07	75546459.01	0.9070	68522865.32	229812.80	83939125.02
2023	2.52	1.03	100480.92	252895.86	365.25	92370211.04	78514679.39	0.8638	67823932.09	232110.93	84778516.27
2024	2.59	1.03	101485.73	262832.13	365.25	95999436.63	81599521.14	0.8227	67132127.98	234432.04	85626301.43
2025	2.66	1.03	102500.59	273158.81	365.25	99771254.50	84805566.32	0.7835	66447380.28	236776.36	86482564.44
2026	2.74	1.03	103525.59	283891.22	365.25	103691267.09	88137577.02	0.7462	65769617.00	239144.12	87347390.09
2027	2.82	1.03	104560.85	295045.30	365.25	107765296.97	91600502.43	0.7107	65098766.90	241535.56	88220863.99
2028	2.90	1.03	105606.46	306637.63	365.25	111999395.49	95199486.17	0.6768	64434759.48	243950.92	89103072.63
2029	2.99	1.03	106662.52	318685.43	365.25	116399851.74	98939873.98	0.6446	63777524.94	246390.43	89994103.36
2030	3.07	1.03	107729.15	331206.58	365.25	120973201.91	102827221.63	0.6139	63126994.18	248854.33	90894044.39
2031	3.16	1.03	108806.44	344219.68	365.25	125726239.02	106867303.16	0.5847	62483098.84	251342.87	91802984.83
2032	3.26	1.03	109894.50	357744.07	365.25	130666022.95	111066119.51	0.5568	61845771.23	253856.30	92721014.68
2033	3.35	1.03	110993.45	371799.84	365.25	135799890.99	115429907.34	0.5303	61214944.37	256394.87	93648224.83
2034	3.45	1.03	112103.38	386407.85	365.25	141135468.71	119965148.40	0.5051	60590551.93	258958.81	94584707.08
2035	3.55	1.03	113224.42	401589.82	365.25	146680681.27	124678579.08	0.4810	59972528.30	261548.40	95530554.15
2036	3.65	1.03	114356.66	417368.28	365.25	152443765.24	129577200.45	0.4581	59360808.52	264163.89	96485859.69
2037	3.76	1.03	115500.23	433766.68	365.25	158433280.78	134668288.66	0.4363	58755328.27	266805.53	97450718.29
2038	3.86	1.03	116655.23	450809.38	365.25	164658124.38	139959405.72	0.4155	58156023.92	269473.58	98425225.47
2039	3.98	1.03	117821.78	468521.68	365.25	171127542.08	145458410.77	0.3957	57562832.48	272168.32	99409477.72
2040	4.09	1.03	119000.00	486929.89	365.25	177851143.21	151173471.73	0.3769	56975691.58	274890.00	100403572.50
2041	4.21	1.03	120190.00	506061.37	365.25	184838914.63	157113077.43	0.3589	56394539.53	277638.90	101407608.23
2042	4.33	1.03	121391.90	525944.52	365.25	192101235.58	163286050.25	0.3418	55819315.23	280415.29	102421684.31
2043	4.46	1.03	122605.82	546608.88	365.25	199648893.13	169701559.16	0.3256	55249958.21	283219.44	103445901.15
2044	4.59	1.03	123831.88	568085.14	365.25	207493098.14	176369133.42	0.3101	54686408.64	286051.64	104480360.16
2045	4.72	1.03	125070.20	590405.21	365.25	215645501.97	183298676.67	0.2953	54128607.27	288912.15	105525163.76
2046	4.86	1.03	126320.90	613602.23	365.25	224118213.74	190500481.68	0.2812	53576495.48	291801.27	106580415.40
2047	5.00	1.03	127584.11	637710.66	365.25	232923818.36	197985245.60	0.2678	53030015.22	294719.29	107646219.56
2048	5.14	1.03	128859.95	662766.31	365.25	242075395.18	205764085.90	0.2551	52489109.07	297666.48	108722681.75
2049	5.29	1.03	130148.55	688806.40	365.25	251586537.46	213848556.84	0.2429	51953720.15	300643.14	109809908.57
2050	5.45	1.03	131450.03	715869.60	365.25	261471372.52	222250666.64	0.2314	51423792.21	303649.58	110908007.65
2051	5.60	1.03	132764.53	743996.12	365.25	271744582.74	230982895.33	0.2204	50899269.53	306686.07	112017087.73
2052	5.77	1.03	134092.18	773227.73	365.25	282421427.40	240058213.29	0.2099	50380096.98	309752.93	113137258.61
2053	5.93	1.03	135433.10	803607.84	365.25	293517765.28	249490100.49	0.1999	49866219.99	312850.46	114268631.19
2054	6.11	1.03	136787.43	835181.60	365.25	305050078.28	259292566.54	0.1904	49357584.55	315978.97	115411317.51
2055	6.28	1.03	138155.31	867995.88	365.25	317035495.85	269480171.48	0.1813	48854137.18	319138.76	116565430.68
2056	6.46	1.03	139536.86	902099.44	365.25	329491820.49	280068047.41	0.1727	48355824.98	322330.14	117731084.99
2057	6.65	1.03	140932.23	937542.93	365.25	342437554.11	291071921.00	0.1644	47862595.57	325553.45	118908395.84
2058	6.85	1.03	142341.55	974378.99	365.25	355891925.61	302508136.77	0.1566	47374397.09	328808.98	120097479.80
2059	7.04	1.03	143764.97	1012662.34	365.25	369874919.37	314393681.46	0.1491	46891178.24	332097.07	121298454.59
Total						7689542181.42	6536110854.21		2259925049.36	11013346.06	4022624649.52

Table D9: High Desert Corridor

Year	Toll Rate	Infla-tion	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue	NPV	Net Gross
2020	16.94	1.03	44243.11	749478.25	365.25	273746932.07	232684892.26	1.00	232684892.26	749478.25	273746932.07
2021	17.43	1.03	44685.54	778925.25	365.25	284502449.03	241827081.67	0.95	230311506.36	756973.04	276484401.39
2022	17.94	1.03	45132.39	809529.23	365.25	295680550.25	251328467.71	0.91	227962328.99	764542.77	279249245.40
2023	18.46	1.03	45583.72	841335.63	365.25	307297839.07	261203163.21	0.86	225637113.24	772188.19	282041737.86
2024	18.99	1.03	46039.56	874391.71	365.25	319371571.17	271465835.49	0.82	223335614.68	779910.08	284862155.23
2025	19.54	1.03	46499.95	908746.56	365.25	331919680.20	282131728.17	0.78	221057591.41	787709.18	287710776.79
2026	20.11	1.03	46964.95	944451.21	365.25	344960804.43	293216683.77	0.75	218802803.98	795586.27	290587884.55
2027	20.69	1.03	47434.60	981558.70	365.25	358514314.44	304737167.27	0.71	216571015.38	803542.13	293493763.40
2028	21.29	1.03	47908.95	1020124.14	365.25	372600341.85	316710290.58	0.68	214361991.02	811577.55	296428701.03
2029	21.91	1.03	48388.04	1060204.82	365.25	387239809.29	329153837.89	0.64	212175498.71	819693.33	299392988.04
2030	22.55	1.03	48871.92	1101860.26	365.25	402454461.39	342086292.18	0.61	210011308.63	827890.26	302386917.93
2031	23.20	1.03	49360.64	1145152.35	365.25	418266897.18	355526862.60	0.58	207869193.28	836169.16	305410787.10
2032	23.87	1.03	49854.24	1190145.39	365.25	434700603.57	369495513.03	0.56	205748927.51	844530.86	308464894.98
2033	24.56	1.03	50352.78	1236906.20	365.25	451779990.28	384012991.74	0.53	203650288.45	852976.16	311549543.93
2034	25.28	1.03	50856.31	1285504.25	365.25	469530426.10	399100862.19	0.51	201573055.50	861505.93	314665039.36
2035	26.01	1.03	51364.88	1336011.71	365.25	487978276.54	414781535.06	0.48	199517010.34	870120.98	317811689.76
2036	26.76	1.03	51878.52	1388503.61	365.25	507150943.03	431078301.58	0.46	197481936.83	878822.19	320989806.66
2037	27.54	1.03	52397.31	1443057.92	365.25	527076903.58	448015368.04	0.44	195467621.08	887610.42	324199704.72
2038	28.34	1.03	52921.28	1499755.66	365.25	547785755.12	465617891.85	0.42	193473851.34	896486.52	327441701.77
2039	29.16	1.03	53450.50	1558681.06	365.25	569308257.44	483912018.83	0.40	191500418.06	905451.39	330716118.79
2040	30.01	1.03	53985.00	1619921.64	365.25	591676378.88	502924922.05	0.38	189547113.79	914505.90	334023279.98
2041	30.88	1.03	54524.85	1683568.36	365.25	614923343.80	522684842.23	0.36	187613733.23	923650.96	337363512.77
2042	31.77	1.03	55070.10	1749715.76	365.25	639083681.98	543221129.68	0.34	185700073.15	932887.47	340737147.90
2043	32.69	1.03	55620.80	1818462.09	365.25	664193279.85	564564287.87	0.33	183805932.41	942216.34	344144519.38
2044	33.64	1.03	56177.01	1889909.47	365.25	690289433.81	586746018.74	0.31	181931111.90	951638.51	347585964.58
2045	34.62	1.03	56738.78	1964164.01	365.25	717410905.67	609799269.82	0.30	180075414.56	961154.89	351061824.22
2046	35.62	1.03	57306.17	2041336.02	365.25	745597980.15	633758283.13	0.28	178238645.33	970766.44	354572442.46
2047	36.65	1.03	57879.23	2121540.11	365.25	774892524.79	658658646.07	0.27	176420611.15	980474.11	358118166.89
2048	37.72	1.03	58458.02	2204895.42	365.25	805338052.09	684537344.28	0.26	174621120.91	990278.85	361699348.56
2049	38.81	1.03	59042.60	2291525.76	365.25	836979784.15	711432816.53	0.24	172839985.48	1000181.63	365316342.04
2050	39.94	1.03	59633.03	2381559.81	365.25	869864719.87	739385011.89	0.23	171077017.63	1010183.45	368969505.46
2051	41.10	1.03	60229.36	2475131.29	365.25	904041704.72	768435449.01	0.22	169332032.05	1020285.29	372659200.52
2052	42.29	1.03	60831.65	2572379.20	365.25	939561503.30	798627277.80	0.21	167604845.32	1030488.14	376385792.52
2053	43.51	1.03	61439.97	2673447.98	365.25	976476874.76	830005343.55	0.20	165895275.90	1040793.02	380149650.45
2054	44.78	1.03	62054.37	2778487.75	365.25	1014842651.17	862616253.49	0.19	164203144.08	1051200.95	383951146.95
2055	46.07	1.03	62674.91	2887654.54	365.25	1054715818.93	896508446.09	0.18	162528272.01	1061712.96	387790658.42
2056	47.41	1.03	63301.66	3001110.48	365.25	1096155603.46	931732262.94	0.17	160870483.64	1072330.09	391668565.01
2057	48.78	1.03	63934.67	3119024.11	365.25	1139223557.12	968340023.55	0.16	159229604.71	1083053.39	395585250.66
2058	50.20	1.03	64574.02	3241570.57	365.25	1183983650.68	1006386103.08	0.16	157605462.74	1093883.92	399541103.16
2059	51.66	1.03	65219.76	3368931.88	365.25	1230502368.32	1045927013.07	0.15	155997887.02	1104822.76	403536514.19
Total						25581620623.54	21744377530.01		7674331734.02	36639273.72	13382494726.88

Table D10: Glendale-Palmdale Expressway

Year	Toll Rate	Infla-tion	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue	NPV	Net Gross
2020	21.97	1.03	43548.13	956752.52	365.25	349453856.25	297035777.82	1.00	297035777.82	956752.52	349453856.25
2021	22.61	1.03	43983.62	994343.32	365.25	363183898.27	308706313.53	0.95	294006012.88	966320.04	352948394.82
2022	23.26	1.03	44423.45	1033411.07	365.25	377453393.63	320835384.58	0.91	291007151.55	975983.24	356477878.76
2023	23.94	1.03	44867.69	1074013.79	365.25	392283537.46	333441006.85	0.86	288038878.60	985743.07	360042657.55
2024	24.63	1.03	45316.36	1116211.79	365.25	407696357.65	346541904.00	0.82	285100882.04	995600.50	363643084.13
2025	25.35	1.03	45769.53	1160067.76	365.25	423714747.54	360157535.41	0.78	282192853.05	1005556.51	367279514.97
2026	26.08	1.03	46227.22	1205646.82	365.25	440362499.97	374308124.98	0.75	279314485.95	1015612.07	370952310.12
2027	26.84	1.03	46689.49	1253016.68	365.25	457664342.60	389014691.21	0.71	276465478.19	1025768.19	374661833.22
2028	27.62	1.03	47156.39	1302247.71	365.25	475645974.62	404299078.43	0.68	273645530.31	1036025.88	378408451.55
2029	28.42	1.03	47627.95	1353413.02	365.25	494334104.96	420183989.22	0.64	270854345.90	1046386.14	382192536.07
2030	29.24	1.03	48104.23	1406588.62	365.25	513756491.95	436693018.15	0.61	268091631.57	1056850.00	386014461.43
2031	30.09	1.03	48585.28	1461853.48	365.25	533941984.51	453850686.84	0.58	265357096.93	1067418.50	389874606.04
2032	30.96	1.03	49071.13	1519289.71	365.25	554920565.09	471682480.32	0.56	262650454.54	1078092.68	393773352.10
2033	31.86	1.03	49561.84	1578982.60	365.25	576723394.09	490214884.98	0.53	259971419.91	1088873.61	397711085.62
2034	32.78	1.03	50057.46	1641020.82	365.25	599382856.24	509475427.81	0.51	257319711.42	1099762.34	401688196.48
2035	33.73	1.03	50558.03	1705496.53	365.25	622932608.66	529492717.36	0.48	254695050.37	1110759.97	405705078.45
2036	34.71	1.03	51063.61	1772505.49	365.25	647407630.86	550296486.23	0.46	252097160.85	1121867.57	409762129.23
2037	35.72	1.03	51574.25	1842147.23	365.25	672844276.68	571917635.17	0.44	249525769.81	1133086.24	413859750.52
2038	36.75	1.03	52089.99	1914525.20	365.25	699280328.31	594388279.06	0.42	246980606.96	1144417.11	417998348.03
2039	37.82	1.03	52610.89	1989746.89	365.25	726755052.40	617741794.54	0.40	244461404.77	1155861.28	422178331.51
2040	38.92	1.03	53137.00	2067924.05	365.25	755309258.41	642012869.65	0.38	241967898.44	1167419.89	426400114.82
2041	40.05	1.03	53668.37	2149172.78	365.25	784985359.18	667237555.30	0.36	239499825.88	1179094.09	430664115.97
2042	41.21	1.03	54205.05	2233613.78	365.25	815827433.94	693453318.85	0.34	237056927.65	1190885.03	434970757.13
2043	42.40	1.03	54747.10	2321372.47	365.25	847881293.82	720699099.75	0.33	234638946.99	1202793.88	439320464.70
2044	43.63	1.03	55294.58	2412579.19	365.25	881194549.85	749015367.37	0.31	232245629.73	1214821.82	443713669.35
2045	44.90	1.03	55847.52	2507369.43	365.25	915816683.72	778444181.16	0.30	229876724.31	1226970.04	448150806.04
2046	46.20	1.03	56406.00	2605883.97	365.25	951799121.22	809029253.04	0.28	227531981.72	1239239.74	452632314.10
2047	47.54	1.03	56970.06	2708269.15	365.25	989195308.69	840816012.39	0.27	225211155.51	1251632.13	457158637.24
2048	48.92	1.03	57539.76	2814677.05	365.25	1028060792.37	873851673.52	0.26	222914001.72	1264148.46	461730223.62
2049	50.34	1.03	58115.15	2925265.71	365.25	1068453300.90	908185305.77	0.24	220640278.90	1276789.94	466347525.85
2050	51.80	1.03	58696.31	3040199.40	365.25	1110432831.10	943867906.43	0.23	218389748.06	1289557.84	471011001.11
2051	53.30	1.03	59283.27	3159648.84	365.25	1154061737.03	980952476.47	0.22	216162172.63	1302453.42	475721111.12
2052	54.84	1.03	59876.10	3283791.44	365.25	1199404822.68	1019494099.28	0.21	213957318.47	1315477.95	480478322.23
2053	56.43	1.03	60474.86	3412811.60	365.25	1246529438.16	1059550022.44	0.20	211774953.82	1328632.73	485283105.46
2054	58.07	1.03	61079.61	3546900.97	365.25	1295505579.79	1101179742.82	0.19	209614849.29	1341919.06	490135936.51
2055	59.75	1.03	61690.41	3686258.71	365.25	1346405994.02	1144445094.91	0.18	207476777.83	1355338.25	495037295.88
2056	61.49	1.03	62307.31	3831091.82	365.25	1399306285.52	1189410342.69	0.17	205360514.69	1368891.63	499987668.83
2057	63.27	1.03	62930.38	3981615.41	365.25	1454285029.48	1236142275.06	0.16	203265837.44	1382580.55	504987545.52
2058	65.10	1.03	63559.69	4138053.08	365.25	1511423888.29	1284710305.04	0.16	201192525.90	1396406.35	510037420.98
2059	66.99	1.03	64195.29	4300637.19	365.25	1570807732.86	1335186572.93	0.15	199140362.14	1410370.42	515137795.19
Total						32656424342.76	27757960691.35		9796730134.55	46772160.68	17083531688.51

Table D11: Irvine-Corona Expressway

Year	Toll Rate	Infla-tion	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue	NPV	Net Gross
2020	8.67	1.03	39502.04	342482.72	365.25	125091812.34	106328040.49	1.00	106328040.49	342482.7169	125091812.3
2021	10.00	1.03	39897.06	398970.64	365.25	145724025.91	123865422.03	0.95	117967068.60	345907.5441	126342730.5
2022	10.29	1.03	40296.03	414646.20	365.25	151449522.89	128732094.46	0.91	116763804.50	349366.6195	127606157.8
2023	10.59	1.03	40698.99	430937.64	365.25	157399974.65	133789978.45	0.86	115572813.69	352860.2857	128882219.3
2024	10.90	1.03	41105.98	447869.18	365.25	163584219.65	139046586.70	0.82	114393970.99	356388.8885	130171041.5
2025	11.21	1.03	41517.04	465465.96	365.25	170011443.64	144509727.09	0.78	113227152.49	359952.7774	131472752
2026	11.54	1.03	41932.22	483754.12	365.25	176691193.26	150187514.27	0.75	112072235.53	363552.3052	132787479.5
2027	11.87	1.03	42351.54	502760.82	365.25	183633390.24	156088381.71	0.71	110929098.73	367187.8283	134115354.3
2028	12.22	1.03	42775.05	522514.29	365.25	190848346.15	162221094.22	0.68	109797621.92	370859.7065	135456507.8
2029	12.57	1.03	43202.80	543043.88	365.25	198346777.67	168594761.02	0.64	108677686.18	374568.3036	136811072.9
2030	12.93	1.03	43634.83	564380.08	365.25	206139822.56	175218849.18	0.61	107569173.78	378313.9866	138179183.6
2031	13.31	1.03	44071.18	586554.57	365.25	214239056.19	182103197.76	0.58	106471968.21	382097.1265	139560975.5
2032	13.70	1.03	44511.89	609600.30	365.25	222656508.71	189258032.40	0.56	105385954.13	385918.0978	140956585.2
2033	14.09	1.03	44957.01	633551.49	365.25	231404682.93	196693980.49	0.53	104311017.40	389777.2788	142366151.1
2034	14.50	1.03	45406.58	658443.73	365.25	240496572.93	204422086.99	0.51	103247045.02	393675.0515	143789812.6
2035	14.92	1.03	45860.65	684313.99	365.25	249945683.28	212453830.78	0.48	102193925.16	397611.8021	145227710.7
2036	15.35	1.03	46319.25	711200.68	365.25	259766049.17	220801141.80	0.46	101151547.13	401587.9201	146679987.8
2037	15.80	1.03	46782.45	739143.76	365.25	269972257.24	229476418.66	0.44	100119801.34	405603.7993	148146787.7
2038	16.26	1.03	47250.27	768184.72	365.25	280579467.23	238492547.15	0.42	99098579.37	409659.8373	149628255.6
2039	16.73	1.03	47722.77	798366.69	365.25	291603434.50	247862919.32	0.40	98087773.86	413756.4356	151124538.1
2040	17.21	1.03	48200.00	829734.52	365.25	303060533.44	257601453.42	0.38	97087278.57	417894	152635783.5
2041	17.71	1.03	48682.00	862334.79	365.25	314967781.80	267722614.53	0.36	96096988.33	422072.94	154162141.3
2042	18.23	1.03	49168.82	896215.92	365.25	327342865.95	278241436.05	0.34	95116799.05	426293.6694	155703762.7
2043	18.76	1.03	49660.51	931428.25	365.25	340204167.15	289173542.08	0.33	94146607.70	430556.6061	157260800.4
2044	19.30	1.03	50157.11	968024.06	365.25	353570788.88	300535170.54	0.31	93186312.30	434862.1722	158833408.4
2045	19.86	1.03	50658.68	1006057.73	365.25	367462585.17	312343197.40	0.30	92235811.91	439210.7939	160421742.5
2046	20.44	1.03	51165.27	1045585.74	365.25	381900190.14	324615161.62	0.28	91295006.63	443602.9018	162025959.9
2047	21.03	1.03	51676.92	1086666.80	365.25	396905048.61	337369291.32	0.27	90363797.56	448038.9308	163646219.5
2048	21.64	1.03	52193.69	1129361.94	365.25	412499447.97	350624530.78	0.26	89442086.83	452519.3201	165282681.7
2049	22.27	1.03	52715.63	1173734.57	365.25	428706551.28	364400568.59	0.24	88529777.54	457044.5133	166935508.5
2050	22.91	1.03	53242.79	1219850.60	365.25	445550431.68	378717866.93	0.23	87626773.81	461614.9585	168604863.6
2051	23.58	1.03	53775.21	1267778.53	365.25	463056108.14	393597691.92	0.22	86732980.72	466231.1081	170290912.2
2052	24.26	1.03	54312.97	1317589.55	365.25	481249582.63	409062145.24	0.21	85848304.31	470893.4191	171993821.3
2053	24.96	1.03	54856.10	1369357.64	365.25	500157878.74	425134196.92	0.20	84972651.61	475602.3533	173713759.6
2054	25.69	1.03	55404.66	1423159.70	365.25	519809081.79	441837719.52	0.19	84105930.56	480358.3769	175450897.2
2055	26.43	1.03	55958.70	1479075.65	365.25	540232380.61	459197523.52	0.18	83248050.07	485161.9606	177205406.1
2056	27.20	1.03	56518.29	1537188.53	365.25	561458110.85	477239394.22	0.17	82398919.96	490013.5802	178977460.2
2057	27.99	1.03	57083.47	1597584.67	365.25	583517800.02	495990130.02	0.16	81558450.98	494913.716	180767234.8
2058	28.80	1.03	57654.31	1660353.77	365.25	606444214.39	515477582.23	0.16	80726554.78	499862.8532	182574907.1
2059	29.63	1.03	58230.85	1725589.07	365.25	630271407.57	535730696.43	0.15	79903143.92	504861.4817	184400656.2
Total						13087951197.95	11124758518.26		3917988505.65	16742737.97	6115285042.33

Table D12: Cross Mountain Tunnel

Year	Toll Rate	Inflation	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2020	7.83	1.03	42011.49	328949.96	365.25	120148971.44	102126625.73	1.00	102126625.73
2021	8.06	1.03	42431.60	341874.40	365.25	124869624.53	106139180.85	0.95	101084934.14
2022	8.29	1.03	42855.92	355306.64	365.25	129775752.08	110309389.27	0.91	100053867.82
2023	8.53	1.03	43284.48	369266.64	365.25	134874641.38	114643445.17	0.86	99033318.36
2024	8.78	1.03	43717.32	383775.13	365.25	140173866.04	119147786.13	0.82	98023178.52
2025	9.03	1.03	44154.50	398853.65	365.25	145681297.23	123829102.65	0.78	97023342.10
2026	9.30	1.03	44596.04	414524.61	365.25	151405115.40	128694348.09	0.75	96033704.01
2027	9.56	1.03	45042.00	430811.29	365.25	157353822.39	133750749.03	0.71	95054160.23
2028	9.84	1.03	45492.42	447737.86	365.25	163536254.07	139005815.96	0.68	94084607.79
2029	10.13	1.03	45947.35	465329.48	365.25	169961593.49	144467354.47	0.64	93124944.79
2030	10.42	1.03	46406.82	483612.28	365.25	176639384.50	150143476.82	0.61	92175070.36
2031	10.72	1.03	46870.89	502613.40	365.25	183579545.92	156042614.03	0.58	91234884.64
2032	11.03	1.03	47339.60	522361.08	365.25	190792386.28	162173528.33	0.56	90304288.81
2033	11.35	1.03	47812.99	542884.65	365.25	198288619.13	168545326.26	0.53	89383185.07
2034	11.68	1.03	48291.12	564214.59	365.25	206079378.98	175167472.13	0.51	88471476.58
2035	12.02	1.03	48774.03	586382.58	365.25	214176237.78	182049802.11	0.48	87569067.52
2036	12.37	1.03	49261.77	609421.55	365.25	222591222.16	189202538.84	0.46	86675863.03
2037	12.73	1.03	49754.39	633365.73	365.25	231336831.28	196636306.59	0.44	85791769.23
2038	13.10	1.03	50251.94	658250.66	365.25	240426055.38	204362147.07	0.42	84916693.18
2039	13.48	1.03	50754.46	684113.33	365.25	249872395.10	212391535.83	0.40	84050542.91
2040	13.87	1.03	51262.00	710992.15	365.25	259689881.50	220736399.27	0.38	83193227.37
2041	14.27	1.03	51774.62	738927.03	365.25	269893096.94	229409132.40	0.36	82344656.45
2042	14.69	1.03	52292.37	767959.47	365.25	280497196.72	238422617.21	0.34	81504740.96
2043	15.11	1.03	52815.29	798132.60	365.25	291517931.58	247790241.84	0.33	80673392.60
2044	15.55	1.03	53343.44	829491.23	365.25	302971671.11	257525920.45	0.31	79850524.00
2045	16.00	1.03	53876.88	862081.94	365.25	314875428.07	267644113.86	0.30	79036048.65
2046	16.46	1.03	54415.65	895953.14	365.25	327246883.64	278159851.09	0.28	78229880.96
2047	16.94	1.03	54959.80	931155.14	365.25	340104413.70	289088751.64	0.27	77431936.17
2048	17.43	1.03	55509.40	967740.22	365.25	353467116.11	300447048.70	0.26	76642130.42
2049	17.94	1.03	56064.49	1005762.74	365.25	367354839.10	312251613.24	0.24	75860380.69
2050	18.46	1.03	56625.14	1045279.15	365.25	381788210.73	324519979.12	0.23	75086604.81
2051	18.99	1.03	57191.39	1086348.17	365.25	396788669.53	337270369.10	0.22	74320721.44
2052	19.55	1.03	57763.30	1129030.79	365.25	412378496.36	350521721.90	0.21	73562650.08
2053	20.11	1.03	58340.94	1173390.41	365.25	428580847.48	364293720.36	0.20	72812311.05
2054	20.70	1.03	58924.35	1219492.92	365.25	445419788.98	378606820.63	0.19	72069625.48
2055	21.30	1.03	59513.59	1267406.80	365.25	462920332.49	393482282.61	0.18	71334515.30
2056	21.91	1.03	60108.73	1317203.21	365.25	481108472.35	408942201.50	0.17	70606903.24
2057	22.55	1.03	60709.81	1368956.12	365.25	500011224.23	425009540.59	0.16	69886712.83
2058	23.20	1.03	61316.91	1422742.41	365.25	519656665.23	441708165.44	0.16	69173868.36
2059	23.88	1.03	61930.08	1478641.96	365.25	540073975.61	459062879.26	0.15	68468294.90
Total						11227908136.01	9543721915.61		3368304650.55

Table D13: Downtown Bypass Tunnel

Year	Toll Rate	Inflation	Traffic Count	Revenue	Days of Year	Total Gross Revenue	Net Revenue	NPV Factor	NPV Revenue
2020	6.01	1.03	76439.73	459402.79	365.25	167796869.44	142627339.03	1.00	142627339.03
2021	6.18	1.03	77204.13	477452.73	365.25	174389608.44	148231167.18	0.95	141172540.17
2022	6.36	1.03	77976.17	496211.84	365.25	181241376.16	154055169.73	0.91	139732580.26
2023	6.55	1.03	78755.93	515708.01	365.25	188362349.83	160107997.35	0.86	138307307.94
2024	6.74	1.03	79543.49	535970.18	365.25	195763106.55	166398640.57	0.82	136896573.40
2025	6.93	1.03	80338.93	557028.44	365.25	203454639.01	172936443.16	0.78	135500228.35
2026	7.13	1.03	81142.32	578914.09	365.25	211448371.78	179731116.01	0.75	134118126.02
2027	7.34	1.03	81953.74	601659.63	365.25	219756178.30	186792751.56	0.71	132750121.14
2028	7.55	1.03	82773.28	625298.83	365.25	228390398.55	194131838.77	0.68	131396069.90
2029	7.77	1.03	83601.01	649866.82	365.25	237363857.31	201759278.71	0.64	130055829.99
2030	8.00	1.03	84437.02	675400.09	365.25	246689883.26	209686400.77	0.61	128729260.52
2031	8.23	1.03	85281.39	701936.56	365.25	256382328.77	217924979.46	0.58	127416222.06
2032	8.47	1.03	86134.20	729515.65	365.25	266455590.47	226487251.90	0.56	126116576.60
2033	8.72	1.03	86995.55	758178.32	365.25	276924630.62	235385936.03	0.53	124830187.52
2034	8.97	1.03	87865.50	787967.14	365.25	287804999.36	244634249.45	0.51	123556919.60
2035	9.23	1.03	88744.16	818926.37	365.25	299112857.78	254245929.11	0.48	122296639.02
2036	9.50	1.03	89631.60	851101.99	365.25	310865001.96	264235251.67	0.46	121049213.31
2037	9.77	1.03	90527.91	884541.79	365.25	323078887.89	274617054.71	0.44	119814511.33
2038	10.05	1.03	91433.19	919295.43	365.25	335772657.40	285406758.79	0.42	118592403.31
2039	10.35	1.03	92347.52	955414.55	365.25	348965165.11	296620390.34	0.40	117382760.80
2040	10.65	1.03	93271.00	992952.79	365.25	362676006.44	308274605.48	0.38	116185456.64
2041	10.95	1.03	94203.71	1031965.90	365.25	376925546.74	320386714.73	0.36	115000364.98
2042	11.27	1.03	95145.75	1072511.85	365.25	391734951.47	332974708.75	0.34	113827361.26
2043	11.60	1.03	96097.20	1114650.84	365.25	407126217.71	346057285.05	0.33	112666322.18
2044	11.94	1.03	97058.18	1158445.47	365.25	423122206.80	359653875.78	0.31	111517125.69
2045	12.28	1.03	98028.76	1203960.79	365.25	439746678.31	373784676.56	0.30	110379651.01
2046	12.64	1.03	99009.05	1251264.41	365.25	457024325.30	388470676.51	0.28	109253778.57
2047	13.00	1.03	99999.14	1300426.59	365.25	474980811.04	403733689.39	0.27	108139390.03
2048	13.38	1.03	100999.13	1351520.35	365.25	493642807.11	419596386.04	0.26	107036368.25
2049	13.77	1.03	102009.12	1404621.58	365.25	513038033.00	436082328.05	0.24	105944597.29
2050	14.17	1.03	103029.21	1459809.16	365.25	533195297.32	453216002.72	0.23	104863962.40
2051	14.58	1.03	104059.50	1517165.07	365.25	554144540.55	471022859.46	0.22	103794349.98
2052	15.00	1.03	105100.10	1576774.48	365.25	575916879.55	489529347.61	0.21	102735647.61
2053	15.44	1.03	106151.10	1638725.95	365.25	598544653.74	508762955.68	0.20	101687744.01
2054	15.89	1.03	107212.61	1703111.49	365.25	622061473.19	528752252.21	0.19	100650529.02
2055	16.35	1.03	108284.74	1770026.74	365.25	646502268.47	549526928.20	0.18	99623893.62
2056	16.82	1.03	109367.58	1839571.10	365.25	671903342.60	571117841.21	0.17	98607729.91
2057	17.31	1.03	110461.26	1911847.84	365.25	698302424.93	593557061.19	0.16	97601931.06
2058	17.81	1.03	111565.87	1986964.35	365.25	725738727.20	616877918.12	0.16	96606391.37
2059	18.33	1.03	112681.53	2065032.17	365.25	754253001.80	641115051.53	0.15	95621006.17
Total						15680598951.24	13328509108.55		4704085011.30

Table D14: All Expressway Extension/Tunnel Projects Costs

Inflation Rate	Year	IH-710T	HDC	GPT	ICE	XMT	DBT	Total
	2009	6.3	9.8	19	7.4	10.2	4.7	57.4
1.029	2010	6.426	9.996	19.38	7.548	10.404	4.794	
1.029	2011	6.612354	10.285884	19.94202	7.766892	10.705716	4.933026	
	2012	6.804112266	10.58417464	20.52033858	7.992131868	11.01618176	5.076083754	
	2013	7.001431522	10.8911157	21.1154284	8.223903692	11.33565104	5.223290183	
	2014	7.204473036	11.20695806	21.72777582	8.462396899	11.66438492	5.374765598	
	2015	7.413402754	11.53195984	22.35788132	8.707806409	12.00265208	5.530633801	67.5443362
		67.5443362						
		Toll	Toll	Toll	Toll	Toll		
		2.00	14.68	8.67	19.04	6.79	5.21	
	2016	2.06	15.11	8.92	19.59	6.99	5.36	
	2017	2.12	15.54	9.18	20.16	7.19	5.52	
	2018	2.18	15.99	9.45	20.74	7.40	5.68	
	2019	2.24	16.46	9.72	21.35	7.61	5.84	
	2020	2.31	16.94	10.00	21.97	7.83	6.01	
	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue		
	296536110.00	461278392.00	894315252.00	348312256.40	480106084.00	221225352.00	2701773446.40	
	305135657.19	474655465.37	920250394.31	358413311.84	494029160.44	227640887.21		
	313984591.25	488420473.86	946937655.74	368807297.88	508356006.09	234242472.94		
	323090144.39	502584667.61	974398847.76	379502709.52	523098330.27	241035504.65		
	332459758.58	517159622.97	1002656414.34	390508288.09	538268181.84	248025534.29		
	342101091.58	532157252.03	1031733450.36	401833028.45	553877959.12	255218274.78		
	352022023.24	547589812.34	1061653720.42	413486186.27	569940419.93	262619604.75		
	362230661.91	563469916.90	1092441678.31	425477285.67	586468692.11	270235573.29		
	372735351.11	579810544.49	1124122486.98	437816126.96	603476284.18	278072404.91		
	383544676.29	596625050.28	1156722039.11	450512794.64	620977096.42	286136504.66		
	394667471.90	613927176.74	1190266978.24	463577665.69	638985432.22	294434463.29		
	406112828.59	631731064.86	1224784720.61	477021417.99	657516009.75	302973062.73		
	417890100.61	650051265.74	1260303477.51	490855039.11	676583974.03	311759281.55		
	430008913.53	668902752.45	1296852278.36	505089835.25	696204909.28	320800300.71		
	442479172.02	688300932.27	1334460994.43	519737440.47	716394851.65	330103509.43		
	455311068.01	708261659.31	1373160363.27	534809826.24	737170302.35	339676511.20		
	468515088.99	728801247.43	1412982013.80	550319311.20	758548241.12	349527130.03		
	482102026.57	749936483.60	1453958492.20	566278571.23	780546140.11	359663416.80		
	496082985.34	771684641.63	1496123288.47	582700649.79	803181978.17	370093655.89		
	510469391.91	794063496.23	1539510863.84	599598968.64	826474255.54	380826371.91		
	525273004.28	817091337.63	1584156678.89	616987338.73	850442008.95	391870336.69		
	540505921.40	840786986.42	1630097222.58	634879971.55	875104827.21	403234576.46		
	556180593.12	865169809.02	1677370042.03	653291490.73	900482867.20	414928379.17		
	572309830.32	890259733.48	1726013773.25	672236943.96	926596870.35	426961302.17		
	588906815.40	916077265.76	1776068172.68	691731815.33	953468179.59	439343179.93	Total	
	10670655277.54	16598797050.41	32181341299.50	12533785571.63	17276299061.90	7960647591.43	97221525852.42	

Appendix E: Transit System Details

Appendix E provides details on specific transit components beyond what is included in the body of the report. It is intended to provide more details on specific aspects of transit service.

A. Existing Transit Service Guide

The following table provides detail on current heavy rail, light rail, commuter rail, express bus, and bus rapid transit services operating in Southern California.

Table E1: Primary Rail and Bus Service Guide

Line	Mode	Origin	Destination	Rush Headway	Midday Headway	Evening Headway	Weekend	Weekend Night
Red	HRT	Union Station	North Hollywood	10	12	20	12-15	10 Sat 20 Sun
Purple	HRT	Union Station	Wilshire/ Western	10	12	20	12-15	10 Sat 20 Sun
Green	LRT	Redondo Beach	Norwalk	6	15	20	15	20
Blue	LRT	Metro Center	Long Beach	6	12	10	12-15	10
Expo	LRT	Metro Center	Culver City	12	12	10	12-15	10
Gold	LRT	East Los Angeles	Pasadena	6	12	10	8-15	10
Orange	BRT	North Hollywood	Chatsworth	5	8	15-30	10	15-30
Silver	BRT	Harbor Gateway	El Monte	5	15	15-20	20	40
Antelope Valley	CRT	Union 15Station	Lancaster	30 peak 60 rev	60	N/A	90-120	N/A
Inland Empire Orange County	CRT	Oceanside	San Bernardino	30 peak 45 rev	150	N/A	120*	N/A
Orange County	CRT	Oceanside	Union Station	30 peak 90 rev	180	N/A	180	N/A
Riverside	CRT	Riverside	Union Station	40 peak 1 train rev	N/A	N/A	N/A	N/A
San Bernardino	CRT	Riverside	Union Station	30 peak 120 rev	60	90	120	120 Sat. only
Ventura	CRT	East Ventura	Union Station	30 peak 30 rev	180	N/A	N/A	N/A
91	CRT	Riverside	Union Station	40 peak 45 rev	240	N/A	120	N/A
704	BRT	Downtown L.A.	Santa Monica	15 morn 10 aftn	20	N/A	20	N/A
705	BRT	Vernon	West Hollywood	10 morn 15 aftn	30	N/A	N/A	N/A
710	BRT	Wilshire Center	South Bay Galleria	10 morn 15 aftn	18	30	20	20
720	BRT	Santa Monica	Commerce	10 morn 5 aftn	8	10	15	10
728	BRT	Downtown Los Angeles	Century City	12	30	30	N/A	N/A
733	BRT	Downtown Los Angeles	Santa Monica	7 morn 12 aftn	15	30	15-20	30
734	BRT	Sherman Oaks	Sylmar Station	12 morn 18 aftn	35	30	N/A	N/A

Table E1: Primary Rail and Bus Service Guide

Line	Mode	Origin	Destination	Rush Headway	Midday Headway	Evening Headway	Weekend	Weekend Night
740	BRT	Jefferson Park	South Bay Galleria	15	30	25	20 Sat. Only	20 Sat. Only
741	BRT	Northridge	Tarzana	16	30	30-60	N/A	N/A
745	BRT	Downtown Los Angeles	Harbor Freeway Station	5 morn 10 aftn	22	30	12-20	30
750	BRT	Warner Center Transit Hub	Universal City Station	10	30	24	N/A	N/A
751	BRT	Cypress Park	Huntington Park	15	20	30	N/A	N/A
754	BRT	Hollywood	Athens	6	15	20	15-20	20-25
757	BRT	Hawthorne	Hollywood	8	15	20	N/A	N/A
760	BRT	Downtown Los Angeles	Artesia Station	10 morn 15 aftn	25	30	24 Sat. Only	30 Sat. Only
761	BRT	Pacoima	Westwood	10 morn 15 aftn	20	30	30	30
762	BRT	Pasadena	Artesia Blue Line Station	18 morn 25 aftn	30	45-60	N/A	N/A
770	BRT	Downtown Los Angeles	El Monte Station	12	15	30	20 Sat. Only	20 Sat. Only
780	BRT	Washington/Fairfax	Pasadena	10-12	25	25	N/A	N/A
794	BRT	Downtown Los Angeles	Sylmar Station	20	30	50	N/A	N/A
442	Express	Downtown Los Angeles	Hawthorne/ Lennox Station	30-40	N/A	N/A	N/A	N/A
450	Express	Artesia Transit Center	Downtown Los Angeles	16	60	60	40 Sat 60 Sun	40 Sat 60 Sun
460	Express	Downtown Los Angeles	Disneyland	18	27	40	25-30	25-30
485	Express	Downtown Los Angeles	Altadena	35	50	60	N/A	N/A
487	Express	Downtown Los Angeles	El Monte Station	25	40	60	55	55
489	Express	Downtown Los Angeles	Rosemead & Huntington	20	N/A	N/A	N/A	N/A
534	Express	Malibu	Washington/ Fairfax Transit Hub	12	30	50	30-50	55
550	Express	Exposition Park	San Pedro	30	60	60	60	60
577X	Express	El Monte Station	Long Beach VA Medical Center	35	45	55	N/A	N/A
OCTA 206	Express	Santa Ana	Lake Forest	30	N/A	N/A	N/A	N/A
OCTA 211	Express	Seal Beach	Irvine	25-30	N/A	N/A	N/A	N/A
OCTA 212	Express	Irvine	San Juan Capistrano	30 morn 75 aftn	N/A	N/A	N/A	N/A
OCTA 213	Express	Brea	Irvine	20-25	N/A	N/A	N/A	N/A
OCTA 216	Express	San Juan Capistrano	Costa Mesa	N/A	N/A	N/A	N/A	N/A
OCTA 701	Express	Huntington Beach	Los Angeles	25	N/A	N/A	N/A	N/A
OCTA 721	Express	Fullerton	Los Angeles	45	N/A	N/A	N/A	N/A
OCTA 757	Express	Pomona	Santa Ana	23 morn 40 aftn	N/A	N/A	N/A	N/A
OCTA 758	Express	Chino	Irvine	20 morn 30 aftn	N/A	N/A	N/A	N/A
OCTA 794	Express	LA Sierra Metrolink	South Coast Plaza	25 morn 40 aftn	N/A	N/A	N/A	N/A
sbX Green Line	BRT	Palm	VA Hospital	10	15	N/A	N/A	N/A
Omnitran Express	Express	Riverside Transcenter	4th Street Transfer Center	20	30	30	N/A	N/A
VV 15	Express Bus	Barstow Hospital	Fontana Metrolink	120	120	N/A	N/A	N/A
NTC Commuter	Express Bus	Hesperia Park and Ride	Fort Irwin	30	N/A	N/A	N/A	N/A
Foothill Silver Streak	BRT	Montclair	Downtown Los Angeles	8	20	30	30	30
Foothill 481	Express	El Monte	Downtown Los Angeles	10-20	N/A	N/A	N/A	N/A
Foothill 493	Express	Diamond Bar	Rowland Heights	10	N/A	N/A	N/A	N/A
Foothill 495	Express	Industry	Downtown Los Angeles	30	N/A	N/A	N/A	N/A
Foothill 497	Express	Chino	Downtown Los Angeles	15-30	N/A	N/A	N/A	N/A
Foothill 498	Express	Azusa	West Covina	5-10	N/A	N/A	N/A	N/A
Foothill 499	Express	San Dimas	Downtown Los Angeles	10	N/A	N/A	N/A	N/A
Foothill 690	Express	Montclair	Lake Metro Station	20-30	N/A	N/A	N/A	N/A
Foothill 699	Express	Montclair	Downtown Los Angeles	7	N/A	N/A	N/A	N/A
RTA 202	Express	Oceanside	Murrieta	40-60	N/A	N/A	N/A	N/A
RTA 204	Express	Riverside	Montclair	45-50	N/A	N/A	N/A	N/A
RTA 206	Express	Temecula	Corona	20-100	N/A	N/A	N/A	N/A
RTA 208	Express	Temecula	Riverside	30-50	N/A	N/A	N/A	N/A

Table E1: Primary Rail and Bus Service Guide

Line	Mode	Origin	Destination	Rush Headway	Midday Headway	Evening Headway	Weekend	Weekend Night
RTA 210/220	Express	Riverside	Palm Desert	40-50	N/A	N/A	N/A	N/A
RTA 212	Express	Hemet	Riverside	30-45	N/A	N/A	N/A	N/A
RTA 216	Express	Riverside	Village at Orange	60-90	55	N/A	180	N/A
RTA 217	Express	San Jacinto	Escondido	30	N/A	N/A	N/A	N/A
Vista Coastal Express	Express	Ventura	Goleta	10-20	50	60	90	N/A
Vista Highway 101 & Conejo Connection	Express	Woodland Hills	Ventura	30-110	60-120	90	70-120 Sat. Only	N/A
Vista Highway 126	Express	Piru	Ventura	20-40	60	N/A	60	N/A
Vista East County	Express	Thousand Oaks	Simi Valley	60-75	60	N/A	90-110 Sat. Only	N/A
Vista CSUCI-Oxnard	Express	Centerpoint Mall	California State University, Channel Islands	60	60	60	60 Sat. Only	N/A
Vista CSUCI-Camarillo	Express	California State University, Channel Islands	Camarillo Metrolink Station	30	30	30	30 Sat. Only	N/A

*rev stands for reverse direction

Appendix F: Mileage-Based User Fees

Mileage-based user fees (MBUFs) are a new method of funding transportation by charging drivers by the distance they travel, not the fuel efficiency of their vehicles. While the gas tax has been the primary funding method over the past 50 years, increasing fuel efficiency standards and the development of hybrid and electric vehicles have reduced gas tax revenue per mile driven. In 10 years the gas tax will no longer be a reliable revenue source for building and maintaining U.S. roadways.

Two national blue-ribbon commissions were tasked with examining solutions to the gas tax. The panels studied a range of options including general revenue funds, sales taxes, special use taxes and other options. Both panels came to the unanimous conclusion that mileage-based user fees were the best solution.

The rest of this appendix has more details on MBUFs, with a focus on Southern California.

A. Mileage-Based User Fees

As part of its long-term plan, SCAG recommends California transition from per-gallon fuel taxes to mileage-based user fees. The agency is ahead of the curve in this regard. Currently, Oregon has a permanent MBUF program while several other states including California are engaged in pilot programs and trials.

There are several reasons to switch to mileage-based user fees. California leads the country in the number of alternative fuel vehicles that pay little or no gas tax. Further, conventional vehicles are increasingly becoming more fuel-efficient. The gasoline-electric hybrid Prius averages 46 miles per gallon, twice the 2014 new vehicle average of 23.[190] As a result, the Prius pays half of the gasoline tax of an average new vehicle. The electric Nissan Leaf does not use gasoline so the Leaf pays no fuel tax at all, yet still wears out roadway pavement like any other vehicle. Over the last 20 years, vehicle fleet fuel efficiency has increased by 25%, resulting in less gas purchased and thereby less gasoline tax incurred.[191] In this way, fuel efficiency improvements have eroded the purchasing power of the gasoline tax. By 2025, average corporate fuel economy must meet a 54.5 miles per gallon standard, significantly worsening the problem.

Inflation has also reduced the purchasing power of the gas tax. California's gasoline tax is not indexed to inflation, necessitating continual fuel tax adjustments. Further, so much of California's gas tax supports non-highway infrastructure, road users justifiably complain that the gasoline tax is no longer a user fee.

As a result, increasing the gas tax is not the best solution. Owners of hybrids and electric vehicles, who tend to be wealthier than the average vehicle owner, will continue to pay less than owners of traditional vehicles, introducing both economic and equity issues. As well, politicians will be tempted to use gas taxes for non-roadway expenses. Further, gas taxes are not the best proxy for roadway usage. Tractor-trailers and other heavy vehicles wear out the road 10 times faster than cars, yet they do not pay 10 times the diesel taxes. Finally, even if gas taxes were increased, they would have to be increased every 10 to 15 years, a political impossibility at the federal level.

With mileage-based user fees (MBUF), drivers pay a per-mile fee to use a certain section of road. The fee could vary based on the type of road; Interstates and expressways would have the highest rate per mile followed by arterials, and then local streets. The fee could vary by time of day. Driving during the height of rush hour would be the most expensive, followed by driving during shoulder periods, and then off-peak hours. The fee varies by type of vehicle. For example, passenger vehicles would pay far less than tractor-trailers.

MBUFs are not intended to be an additional tax. Most states are planning to replace fuel taxes with MBUFs, although the two may co-exist during a transition period. MBUFs are a replacement of the existing revenue source, not an additional revenue source. Some have questioned whether MBUFs will increase the burden on the poor and elderly residents. Studies have found MBUFs are actually more equitable than gas taxes.[192]

There are several types of MBUFs being tested and in operation.[193] They typically fall into one of four categories. The first is a plan that provides unlimited mileage for an annual fee. This option does not require an annual inspection or odometer reading. Vehicle owners pay a flat fee with their vehicle registration. The second is based on a required annual odometer reading. A third, more advanced system would use wireless reporting to monitor miles driven on state roads. This system tracks mileage and uses variable pricing, which charges drivers a higher price during peak hours and a lower price during non-peak hours, but it does not track location. The fourth and most advanced system would use mileage data and vehicle location data. Since these plans have location data, they do not charge for out-of-state or off-road usage. These systems also enable safety warnings and road conditions to be communicated to drivers.

In Oregon, where an extensive pilot program was tested and a permanent MBUF program is being implemented, users are allowed to opt-in to the program.[194] This opt-in process has increased public acceptance, as the current MBUF option allows drivers to save by driving less and no participant pays more than currently paid in fuel taxes.

As part of the Western Road Usage Charge Consortium, California has been studying mileage-based user fees for the past six years. In October 2014, CalTrans and SCAG held a MBUF conference in Glendale.[195] SCAG continues to support MBUF study, development and demonstration of technology related to the Southern California region.[196] As mentioned earlier, SCAG's plan calls for supplementing its transportation funding with revenue from mileage-based user fees, which is contrary to nearly all pilot programs and implementation proposals nationwide. Instead, SCAG should dedicate all revenue from its MBUFs to roadways. As such, MBUFs would be a modern replacement for the gas tax. Funding for transit and active transportation should come from the general fund supplemented with sales tax revenue only where needed.

Endnotes

1 Texas A&M Transportation Institute, *2012 Urban Mobility Report,* (College Station, TX, 2013), p. 18.

2 Carolyn Nguyen, "Los Angeles Tops List of Cities with Worst Traffic Report Says," *ABC 7 Los Angeles*, March 5, 2014, http://abclocal.go.com/kabc/story?id=9455311

3 Andrew Soergel, "Bad Commute? Blame the Job Market," *U.S. News and World Report*, April 17, 2015, http://www.usnews.com/news/articles/2015/04/17/major-metros-set-job-growth-pace-post-recession

4 David Hartgen, M Gregory Fields, Anthony Layzell, Elizabeth San Jose and Baruch Feigenbaum, *Employer Views on Traffic Congestion*, Policy Brief No. 115 (Los Angeles: Reason Foundation, February 2014), pp. 4-12, http://reason.org/files/employer_views_traffic_congestion.pdf

5 Tiffany Hsu, "California's Shrinking Workforce has Troubling Implications," *Los Angeles Times*, December 4, 2014, http://www.latimes.com/business/la-fi-shrinking-workforce-20141204-story.html

6 Gabe Holland and Sam Quinones, "California Demographic Shift: More People Leaving than Moving in," November 27, 2011, http://articles.latimes.com/2011/nov/27/local/la-me-california-move-20111127

7 Paul Sorensen, "Moving Los Angeles," *Access Magazine*, No. 35, Fall 2009, http://uctc.net/access/35/access35_Moving_Los_Angeles.pdf, pp. 16-24.

8 Los Angeles County Metropolitan Transportation Authority, *2001 Long Range Transportation Plan for Los Angeles County Executive Summary,* (Los Angeles, CA 2001), *http://media.metro.net/images/LRTP%20Executive%20Summary.pdf*, cover page.

9 Dowell Myers and John Pitkin, *The Generational Future of Los Angeles: Projections to 2030 and Comparison to Recent Decades, USC Sol Price School of Public Policy*, (Los Angeles, University of Southern California, March 2013), page iii-v, https://www.usc.edu/schools/price/research/popdynamics/futures/2013_Myers-Pitkin_LA-Projections.pdf

10 Joel Kotkin and Wendel Cox, "Southern California Stuck in Drive," *Orange County Register*, October 26, 2014.

11 Texas A&M Transportation Institute, *2015 Urban Mobility Report*, p. 22.

12 Texas A&M Transportation Institute, 2015 Urban Mobility Spreadsheet.

13 Ibid.

14 Ibid.

15 Texas A&M Transportation Institute, *2015 Urban Mobility Report, p. 18,*

16 Ibid.

17 Joel Kotkin, "The Great Train Robbery," Forbes Magazine, http://www.newgeography.com/content/001714-mass-transit-the-great-train-robbery.

18 United States Department of Transportation Federal Highway Administration Office of Operations, *Traffic Congestion and Reliability,* accessed from www.ops.fhwa.dot.gov/congestion_report/executive_summary.htm., 2005

19 The Texas A&M Transportation Institute has defined both a Buffer Index and a Planning Time Index to measure these effects. (http://mobility.tamu.edu/mmp)

20 Texas A&M Transportation Institute, *2012 Urban Mobility Report*, p. 1.

21 Jack Wells, Chief Economist, U.S. Department of Transportation, "The Role of Transportation in the U.S. Economy," presentation to the National Surface Transportation Policy and Revenue Study Commission (Washington D.C., June 26, 2006).

22 U.S. Department of Transportation *National Cooperative Highway Research Program Report 463 Economic Implications of Congestion* (Washington, D.C, Federal Highway Administration, 2001).

23 Ibid.

24 Remy Prud'homme and Chang-Woon Lee, "Size, Sprawl, Speed and the Efficency of Cities," *Urban Studies* Vol. 36, No. 11 (October 1999), pp. 1849-1858.

25 David T. Hartgen and M. Gregory Fields, *Gridlock and Growth: The Effect of Traffic Congestion on Regional Economic Performance,* Policy Study No. 371 (Los Angeles: Reason Foundation, August 2009), http://reason.org/files/ps371_growth_gridlock_cities_full_study.pdf, pp. iii-iv,

26 Southern California Association of Governments, *2008 Regional Transportation Plan*, (Los Angeles, CA, 2008) pp. 2-6.

27 U.S. Department of Commerce, *American FactFinder Table P1*, (Washington, DC 2014), http://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t#none

28 Les Christie, "More Jobs Mean Worse Traffic Congestion," *CNN Money*, March 4, 2011, http://money.cnn.com/2011/03/04/autos/worst_traffic_congestion/

29 "Commuters Suffer Extreme Stress," *BBC News*, November 30, 2004, http://news.bbc.co.uk/1/hi/uk/4052861.stm.

30 Helena Oliviero, "Looking for love in all the close places," *Atlanta Journal-Constitution*, October 15, 2002.

31 Matthew Barth and Kanok Borisboonsomsin, "Traffic Congestion and Greenhouse Gases," *Access*, No. 35, Fall 2009.

[32] Dominic Minadeo, *Price Premiums and Mixed Use Development*, (Nashville, TN: NAIOP Research Foundation 2009), pp. 9-22.

[33] Atlantic Station, *Space For You and Your Guests*, *Parking*, (Atlanta, GA, 2015), http://atlanticstation.com/parking/

[34] U.S. Department of Transportation, *National Cooperative Highway Research Program Report 684, Enhancing Internal Trip Capture Estimation for Mixed use Developments*, (Washington, D.C, Federal Highway Administration, 2011), http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_684.pdf, pp. 25-83,

[35] David Ellis et. al., *Shaping the Competitive Advantage of Texas Metropolitan Regions*, (Austin, TX: Texas Business Leadership Council, 2006), http://www.txblc.org/reports/shaping-the-competitive-advantage-of-texas-metropolitan-regions/

[36] Arizona Department of Transportation, *Phoenix Metro Area Projects*, http://azdot.gov/projects/phoenix-metro-area,

Presidio Parkway-San Francisco Gateway, *Project Overview*, http://www.presidioparkway.org,

California Department of Transportation District 4, *Updates and News Releases*, http://www.dot.ca.gov/dist4/

[37] Southern California Association of Governments, *Programs—Transit Resources and Links*, (Los Angeles, CA 2012), http://www.scag.ca.gov/programs/Pages/TransitResourcesLinks.aspx

[38] Southern California Association of Governments, *2012 Regional Transportation Plan* (Los Angeles, CA 2012), pp. 29-31.

[39] Transportation Demand Management is a set of strategies aimed at reducing single-occupant vehicle travel. The eight most popular TDM strategies are road pricing, parking pricing, pay as you drive insurance, carpooling, transit incentives, transit improvements and telework.

[40] Note the citation for footnote 40: U.S. Government Accountability Office, "Bus Rapid Transit: Projects Improve Transit Service and Can Contribute to Economic Development," (July, 2012), available at http://www.gao.gov/assets/600/592973.pdf

[41] Stephen J. Smith, "Even in Cities with Large Rail Networks Buses Still Rule," *NextCity*, December 19, 2013, http://nextcity.org/daily/entry/even-in-cities-with-large-rail-networks-buses-still-usually-rule

[42] Southern California Association of Governments, *2012 Regional Transportation Plan*, pp. 170-178.

[43] United States Department of Transportation, Federal Highway Administration, Office of Planning, Environment and Reality, *What is Sustainability*, (Washington, DC 2014), https://www.fhwa.dot.gov/livability/

[44] Tax Foundation, *Center for State Tax Policy, California*, http://taxfoundation.org/state-tax-climate/california

[45] United States Department of Labor, Bureau of Labor Statistics, *Labor Underutilization of States Second Quarter of 2014 through First Quarter of 2015 Averages*, (Washington, DC, 2015) http://www.bls.gov/lau/stalt.htm

[46] R. Warren Flint and W. L. Houser, *Living a Sustainable Lifestyle for Our Children's Children*, (San Jose, CA, Author's Choice Press, 2001), pp. 10-14.

[47] "Bill Witte on Housing Affordability: A Supply and Demand Problem," *The Planning Report*, May 28, 2014, http://www.planningreport.com/2014/05/28/bill-witte-housing-affordability-supply-and-demand-problem

[48] Mark Garrett and Brian Taylor, "*Reconsidering Social Equity in Public Transit*, *Berkeley Planning Journal*, Version 13, 1999, pp. 6-27.

[49] Fermin Leal, "California Students Rank 47th in Science," *The Orange County Register*, September 1, 2014, http://www.ocregister.com/articles/students-353581-state-scores.html,

Steven Carroll et. al., *California's K-12 Public School's: How Are They Doing*, (Santa Monica, CA Rand Corporation, 2005), pp. 109-140, http://www.rand.org/content/dam/rand/pubs/monographs/2004/RAND_MG186.pdf

[50] Pricing reduces GHGs just as much as urban growth boundaries.

[51] U.S. Energy Information Administration, *State Level Energy-Related Carbon Dioxide Emissions*, May 27, 2015, http://www.eia.gov/environment/emissions/state/analysis/

[52] Hamilton County Ohio Department of Transportation, *Idling: Frequently Asked Questions*, Updated September 16, 2012, http://www.hcdoes.org/airquality/anti-idling/idlefaq.htm

[53] Bernice Yeung, "California Air Pollution: Report Shows Decrease in Unhealthy Air," *Huffington Post*, http://www.huffingtonpost.com/2012/04/20/california-air-pollution-_n_1440705.html

[54] Bill Vlassic, U.S. Sets Higher Fuel Efficiency Standards, *The New York Times*, August, 28, 2012, http://www.nytimes.com/2012/08/29/business/energy-environment/obama-unveils-tighter-fuel-efficiency-standards.html?_r=0

[55] Wendell Cox and Adrian Moore, *Reducing Greenhouse Gases from Personal Mobility: Opportunities and Possibilities*, Policy Study No. 338, (Los Angeles, Reason Foundation, November 2011), http://reason.org/files/reducing_greenhouse_gases_mobility_development.pdf, p. 23.

[56] David Brownstone, Mark Hansen and Samar Mandanat, *Review of Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study*, ITS Berkeley, Research Report UCB-ITS-RR-2010-1, http://www.its.berkeley.edu/publications/UCB/2010/RR/UCB-ITS-RR-2010-1.pdf

[57] Robert Cervero, "Induced Demand: An Urban and Metropolitan Perspective," paper presented at Policy Forum: Working Together to Address Induced Demand, (Washington, DC 2001), http://www.uctc.net/papers/648.pdf

[58] Adam Gropman, "$1.1 Billion and Five Years Later, the 405 Congestion Relief Project is a Fail," *Los Angeles Weekly*, March 4, 2015, http://www.laweekly.com/news/11-billion-and-five-years-later-the-405-congestion-relief-project-is-a-fail-5415772

[59] Robert Poole, *Reducing Congestion in Atlanta: A Bold New Approach to Increasing Mobility*, Policy Study No. 351, (Los Angeles, Reason Foundation, November 2006), pp. 15–16, http://reason.org/files/d1553a97e45b89fd4de254a121184c4b.pdf

60 http://mobility.tamu.edu/corridors

61 United States Department of Transportation, Federal Highway Administration, *Managed Lanes*, (Washington DC, 2012) http://ops.fhwa.dot.gov/freewaymgmt/managed_lanes.htm

62 Ibid.

63 Raytheon, *The Phantom Tollbooth: How Do Automated Toll Lanes Work*, (Waltham, MA 2014), http://www.raytheon.com/news/feature/electronic_tolling.html

64 United States Department of Transportation, Federal Highway Administration, *Managed Lanes*.

65 European Conference of Ministers of Transport, *Managing Urban Traffic Congestion*, (Brussels Belgium 2007), http://www.internationaltransportforum.org/Pub/pdf/07Congestion.pdf, pp. 167-173.

66 United States Department of Transportation Federal Highway Administration, Managed Lanes.

67 Peter Samuel, "Colorado's Third Toller Is All-Electronic," Tollroadsnews.com, Jan. 1, 2010 (www.tollroadsnews.com/node/4523).

68 Hideo Konishi and Si-il Mun, *Carpooling and Congestion Pricing HOV and HOT Lanes*, (Seoul, South Korea, 2008).

69 Robert W. Poole, Jr. and Ted Balaker, *Virtual Exclusive Busways: Improving Urban Transit while Relieving Congestion*," Policy Study No. 337, (Los Angeles: Reason Foundation, September 2005).

70 Email from Jon Ramirez, Cofiroute USA, the operator of the 91 Express Lanes, Sept. 16, 2005.

71 Email from Chris Tomlinson, GA State Road and Toll Authority, Executive Director SRTA, October 20, 2013.

72 Southern California Association of Governments, 2008 Draft Long Range Transportation Plan*,* p. 12.

73 HNTB, *Priced Managed Lanes*, http://news.hntb.com/images/9055/Collateral/HC108_PricedManagedLanes.pdf, 2012,

Colorado Department of Transportation, High Performance Transportation Enterprise, *Express Lane Corridors*, https://www.codot.gov/programs/high-performance-transportation-enterprise-hpte/projects, 2015,

Joe Rouse, "Managed Lanes in California: Where We Have Been and Where We Are Going, presentation delivered at the Bay Area Meeting of the Institute of Transportation Engineers (San Francisco, CA January 2015)..

74 Transportation Research Board, *Commuting in America Version III*, (Washington, DC: 2006), pp. 87-88.

75 American Association of State Highway and Transportation Officials, *A Policy of Geometric Design of Highways and Streets*, (Washington D.C., 2004), pp. 1-12.

[76] Chris Swenson and Robert Poole, *Reducing Congestion in Lee County Florida*, Policy Study 374, (Los Angeles, Reason Foundation, February 2009), p. 18.

[77] Ibid.

[78] U.S. Department of Transportation, Federal Highway Administration, *2010 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance, Chapter 6* (Washington D.C. June 2011).

[79] Mark Burris, Margie Byers and Chris Swenson, *Lee County Queue Jump Study*, (Washington, DC, 2003), http://www.ltrc.lsu.edu/TRB_82/TRB2003-000678.pdf

[80] Transportation Research Board, Transportation Research Record, *Managed Arterials: New Application of Managed Lanes Concept*, (Washington, DC 2012), p. 66.

[81] Southern California Association of Governments, *2012 Regional Transportation Plan Project List Appendix*, (Los Angeles, CA April 2012), pp. 2-473, http://rtpscs.scag.ca.gov/Documents/2012/final/SR/2012fRTP_ProjectList.pdf

[82] Ibid.

[83] Robert Poole, *Building For The Future Easing California's Transportation Crisis With Tolls and Public-Private Partnerships,* Policy Study No. 324, (Los Angeles, Reason Foundation, March 2005), pp. 13-16.

[84] Southern California Association of Governments, *State Route 14 Corridor Improvement Alternatives Study* (Los Angeles: SCAG, October 2000).

[85] Southern California Regional Rocks and Roads, *Beverly Hills Freeway*, March 1, 2015, http://socalregion.com/highways/la_highways/beverly-hills-freeway/

[86] Southern California Association of Governments, *2008 Regional Transportation Plan: Project List*, p. 194.

[87] Ibid.

[88] The "low" tunnel construction cost of $80 million per lane-mile is based roughly on the actual per lane-mile tunnel construction cost in Dublin, Ireland (tunnel costs reported in China and Madrid, Spain of between $19 million and $48 million per lane-mile were deemed too low to be representative of construction costs in the United States). The "high" tunnel construction cost of $300 million per lane-mile is based roughly on the construction cost estimate of the Alaskan Way Viaduct tunnel option in Seattle, WA (the construction cost of the Big Dig in Boston, MA of $521 million per lane-mile is not used for the cost range due to exceptional conditions associated with that project).

[89] American Association of State Highway and Transportation Officials (ASHTO), *Recommendations for Bridge and Tunnel Security*, The Blue Ribbon Panel on Bridge and Tunnel Security, AASHTO Transportation Security Task Force, Washington, D.C., 2003.

[90] Automobile Association Developments Limited, *Going Underground, Tunnels: What Role in Town and Country,* PA 150 (London, England, June 2001), https://www.theaa.com/public_affairs/reports/going_underground.pdf

[91] Robert Poole and Peter Samuel, *Transportation Mega-Projects and Risk*, Policy Brief No. 97 (Los Angeles, Reason Foundation, February 2011, http://reason.org/files/transportation_mega_projects_risk_big_dig.pdf, p. 8.

[92] A. Dix, "Facilitators Report: Tunnels," paper presented at International Workshop on Tunnel Ventilation, (Sydney, Australia, 2000).

[93] Lindvall, Richter and Associates, "Possible Earthquake Hazards of Tunneling," letter written to the chief engineer of the Southern California Rapid Transit District, (New York, NY January 9, 1978).

[94] American Society of Civil Engineers, Geotechnical Division Journal, (Washington, DC 1978).

[95] Kiyoshi Kanai, Teiji Tanaka and Shizuyo Yoshizawa, Comparative Studies of Earthquake Motions on the Ground and Underground, (Tokyo, Japan: Earthquake Research Institute, 1966).

[96] Charles Richter, *Elementary Seismology*, (New York, New York: WH Freeman and Co., 1958), pp. 21-45.

[97] National Oceanic and Atmospheric Administration (NOAA), 1971 San Fernando Earthquake, (Washington, DC, 1973), Vol. III, p. 214.

[98] Lindvall, Richter and Associates, "Possible Earthquake Hazards of Tunneling."

[99] Cascadia Center, *Large Diameter Soft Ground Bored Tunnel Review*, (Seattle, WA, November 2008), pp. 2-3, http://www.discovery.org/scripts/viewDB/filesDB-download.php?command=download&id=3591

[100] Massachusetts Department of Transportation, *Official Statement for 2010 Sale of Bonds*, (Boston MA, 2009), pp. 32-45, https://www.massdot.state.ma.us/portals/0/docs/InfoCenter/financials/2009AnnualReportDisclosureStatementMHSFYJune2009.pdf

[101] Joanlin Hsu, Shannon McKay, and Markques McKnight, *Cost-Benefit Analysis of Boston's Central Artery/Tunnel*, paper presented at Regional Transportion Workshop (Boston, MA, 2003), slides 12-24.

[102] Florida Department of Transportation District 6, *Port of Miami Tunnel—Project Overview*, (Miami, FL, 2014), http://www.portofmiamitunnel.com/project-overview/project-overview-1/

[103] U.S. Department of Transportation, Federal Highway Administration, *Public-Private Partnership Concessions for Highway Projects: A Primer*, (Washington DC, 2010) http://www.fhwa.dot.gov/ipd/pdfs/p3/p3_concession_primer.pdf.

[104] Ibid, p 39.

[105] Bent Flyvbjerg, et al, Megaprojects and Risk, Cambridge (U.K.): Cambridge University Press, 2003.

[106] Fitch Ratings, *Global Infrastructure and Project Finance*, http://ibtta.org/sites/default/files/documents/IBTTA%20Publications/Fitch%20Ratings%20Global%20PPP%20Lessons%20Learned%202013.pdf, October 2013.

[107] Texas A&M Transportation Institute, *Texas Toll Road Primer Final Report*, (College Station, TX 2014), pp. 20-29, http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/PRC-14-3-F.pdf

[108] Leonard Gilroy and Robert Poole, *Ten Myths and Facts on Transportation Public-Private Partnerships* (Los Angeles: Reason Foundation, 2012), pp. 2–6, http://reason.org/files/ten_myths_and_facts_on_transportation_p3s_(final).pdf.

[109] Randal O'Toole, *Defining Success: The Case Against Rail Transit*, Policy Analysis No. 663 (Washington, D.C., Cato Institute, March 2010), http://object.cato.org/sites/cato.org/files/pubs/pdf/pa663.pdf, p 6

[110] Jeffrey Brown and Gregory Thompson, "Hub Spoke, the Grid, and the Future of Transit: The Importance of System Planning for Public Transit's Success," paper presented at the Future of Transportation Conference, (Tallahassee, FL, September 15-17, 2012.)

[111] "The Effects of Urban Growth Boundaries in Oregon," American Planning Association National Conference, (Seattle, WA, April 19, 2015).

[112] Robert Cervero and Michael Duncan, "Which Reduces Vehicle Travel More," *Journal of the American Planning Association*, vol. 72, no. 4 (Autumn, 2006), pp. 475-490, http://www.uctc.net/papers/825.pdf

[113] Thomas Rubin and Fatma Mansour, "Transit Utilization and Traffic Congestion: Is There a Connection?" Policy Study No. 427, (Los Angeles: Reason Foundation, December 2014), pp. 22-28.

[114] Southern California Association of Governments, *2012 Regional Transportation Plan*, pp. 20-24.

[115] Special Master Donald T Bliss, *Labor/Community Strategy Center et al v Los Angeles County Metropolitan Transportation Authority et al*, No. 94-5936 TJH (MCX, L/CSC *v* MTA, (Los Angeles, CA, January 2004).

[116] Baruch Feigenbaum, *Bus Rapid Transit and Managed Lanes*, Policy Study 432 (Los Angeles, CA., Reason Foundation, January 2014), http://reason.org/files/bus_rapid_transit_and_managed_lanes.pdf, p. 18.

[117] National Bus Rapid Transit Institute, *What is Bus Rapid Transit?* (Tampa, FL, 2006), http://www.nbrti.org

[118] Federal Transit Administration, *Bus Rapid Transit,* (Washington, DC 2011), http://www.fta.dot.gov/about/12351_4240.html

[119] U.S. Department of Transportation, Federal Transit Administration, *Characteristics of Bus Rapid Transit for Decision Makers 2009 Update*, (Washington, DC, 2009), http://www.fta.dot.gov/documents/CBRT_2009_Update.pdf

[120] United States Department of Transportation, Federal Transit Administration, *2008 Bus Rapid Transit Vehicle Demand & System*s, CALSTART Inc, Analysis Report No. FTA-CA-26-7074-2008.1, (Washington, DC, August 2008).

[121] Poole and Balaker, *Virtual Exclusive Busways*, pp. 10-14.

122 Ibid.

123 Ginger Goodin et al., *KATY Freeway*: *An Evaluation of a Second Generation Managed Lanes Project*, (Texas A&M Transportation Institute, September 2013), http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-6688-1.pdf, pp. 141–147.

124 U.S. Government Accountability Office, *Bus Rapid Transit: Projects Improve Transit Service and Can Contribute to Economic Development,* (Washington, DC July, 2012), http://www.gao.gov/assets/600/592973.pdf

125 Los Angeles Metro, *Metro Rapid*, (Los Angeles, CA, 2013), http://www.metro.net/projects/rapid/.

126 Email from Rex Gephart of Los Angeles County Metropolitan Transportation Authority to Robert Poole, August 25, 2008.

127 Los Angeles Metropolitan Transportation Commission, *Lines and Timetables*, (Los Angeles, CA, 2014), http://www.metro.net/riding/maps/

128 Ibid.

129 Metrolink, *Routes*, (Los Angeles, CA 2014), http://www.metrolinktrains.com/routes/

130 Los Angeles Metropolitan Transportation Commission, *Lines and Timetables*.

131 Orange County Transportation Authority, *Bus Transit Routes and Schedules*, (Santa Ana, CA, 2014), http://www.octa.net/Bus-Transit/Routes-and-Schedules/Overview/

132 OmniTrans, *Schedules and Maps*, (San Bernardino, CA, 2014), http://www.omnitrans.org/schedules/

133 Victor Valley Transit Authority, *Bus Routes and Schedules*, (Barstow, CA, 2014), http://vvta.org/bus

134 Foothill Transit, *Lines and Schedules*, (Ontario, CA, 2014), http://foothilltransit.org/lines-and-schedules/

135 Riverside Transit Agency, *Maps and Schedules*, (Riverside, CA, 2014), http://www.riversidetransit.com/index.php/riding-the-bus/maps-schedules

136 Gold Coast Transit, *Current Schedules: Bus Book*, (Oxnard, CA, 2014), http://www.goldcoasttransit.org/schedules/schedules-eff-august24

137 Los Angeles Metropolitan Transportation Commission, *Grow: Projects and Programs*, (Los Angeles, CA, 2014), http://www.metro.net/riding/maps/

138 Los Angeles Metropolitan Transportation Commission, *Lines and Timetables*.

139 Orange County Transportation Authority, *Bus Transit Routes and Schedules*.

140 OmniTrans, *Schedules and Maps*.

141 Victor Valley Transit Authority, *Bus Routes and Schedules*.

142 Foothill Transit, *Lines and Schedules*.

[143] Riverside Transit Agency, *Maps and Schedules*.

[144] Ventura County: VISTA Transit System, *GoVentura*, (Ventura, CA, 2014), http://www.goventura.org/?q=travel-ventura

[145] Priority Signaling was rated as the most important feature by surveys conducted by the Transportation Research Board Bus Rapid Transit Systems Committee, American Public Transit Association Bus Conference and USDOT Secretary of Policy Peter Rogoff.

[146] Rideshare by Enterprise, *Start Vanpooling*, www.enterpriserideshare.com/vanpool/en.html, vRide, *Why vRide,* www.vride.com/why-vride-overview, January 2013.

[147] Casey Phillips, " How Smartphones Revolutionized Society in Less than a Decade," *Chattanooga Times*, November 20, 2014, http://www.govtech.com/products/How-Smartphones-Revolutionized-Society-in-Less-than-a-Decade.html

[148] SF Casual Carpool, *What is Casual Carpool*, (San Francisco, CA, 2014), http://sfcasualcarpool.com

[149] U.S. Department of Transportation, Federal Transit Administration, *Demand Response Service Explained*, (Washington, DC, February 2013).

[150] William Vincent and Lisa Callaghan, "A Preliminary Evaluation of the Metro Orange Line Bus Rapid Transit Project," paper presented at the 2007 Transportation Research Board Annual Meeting, (Washington, DC, January 2007, www.gobrt.org.

[151] Transportation Research Board, National Cooperative Research Program, *The 21st Century Operations-Oriented State DOT*, (Washington DC, 2005), p. 18.

[152] California Center for Innovative Transportation, *Traffic Management, Dynamic Traffic Management Systems*, (Berkeley, CA 2005), http://fresno.ts.odu.edu/newitsd/ITS_Serv_Tech/traff_manag/dyn_trafficmangmt_summary.html

[153] United States Department of Transportation Federal Highway Administration, *Safety Application of Intelligent Transportation Systems in Europe and Japan,* International Technology Scanning Program, (Washington, DC 2006) http://international.fhwa.dot.gov/ipsafety/,

[154] Intelligent Transportation Society of America, *Knowledge Center,* (Washington, DC 2013), http://www.itsa.org/knowledgecenter/knowledge-center-20,

[155] Quickmap, developed by the California Department of Transportation in 2012, provides real time updates on traffic and travel conditions. It is available at http://quickmap.dot.ca.gov

[156] United States Department of Transportation, Federal Highway Administration, *Safety Application of Intelligent Transportation Systems in Europe and Japan*, (Washington, DC 2013), http://www.ops.fhwa.dot.gov/congestion_report/chapter2.htm,

[157] California Department of Transportation, Operations Division, *Frequently Asked Questions*, (Sacrmaneto, 2014) http://www.dot.ca.gov/hq/paffairs/faq/faq66.htm,

158 United States Department of Transportation, *Synthesis of Active Traffic Management Experiences in Europe and the U.S.,3.3 Hard Shoulder Running,* (Washington, DC, 2013), http://ops.fhwa.dot.gov/publications/fhwahop10031/sec3.htm

159 United States Department of Transportation, *Synthesis of Active Traffic Management Experiences in Europe and the U.S., 3.4 Speed Harmonization,* (Washington, DC, 2013), http://ops.fhwa.dot.gov/publications/fhwahop10031/sec3.htm

160 United States Department of Transportation, *Synthesis of Active Traffic Management Experiences in Europe and the U.S., 3.5 Junction Control,* (Washington, DC, 2013), http://ops.fhwa.dot.gov/publications/fhwahop10031/sec3.htm

161 Texas A&M Transportation Institute, *2012 Annual Urban Mobility Report*, p. 51.

162 Ibid.

163 Texas A&M Transportation Institute, *2010 Annual Urban Mobility Report*, (College Station, TX 2011), p. B-28.

164 Minnesota Department of Transportation, *FAQ—Freeway Incident Response Safety Team (FIRST)*, (St. Paul, MN 2008).

165 Ibid, citing ITE Journal, March 1992.

166 Doug MacDonald, "Highway Congestion: What Is to Be Done*?"* briefing to the Washington State Senate Transportation Committee, (Olympia, WA January 17, 2006), www.wsdot.wa.gov/secretary

167 Steve Hemminger, "Metropolitan Transportation Commission Presentation," presentation at the International Bridge, Tunnel and Turnpike Association Conference (Santa Monica, CA, March 21, 2006).

168 National Cooperative Highway Research Program, Safe and Quick Clearance of Traffic Incidents, Synthesis 318, (Washington, DC, 2003), http://trb.org/publications/nchrp/nchrp_syn_318.pdf

169 United States Department of Transportation, Federal Highway Administration, *Traffic Congestion and Reliability: Causes, How They Are Measured and Why They Matter*, (Washington, DC: USDOT, 2014).

170 United States Department of Transportation, Federal Highway Administration, *Traffic Analysis Toolbox Volume VI: Chapter 4.0 Calculation of MOEs by Traffic Analytical Tools*, (Washington, DC 2014), http://ops.fhwa.dot.gov/publications/fhwahop08054/sect4.htm

171 Ibid.

172 These examples are drawn from Samuel Staley and Adrian Moore, *Mobility First: A New Vision for Transportation in a Globally Competitive Twenty-First Century*, (Washington, DC: Rowman and Littlefield, 2008), p. 131.

173 Staley and Moore, *Mobility First*.

174 Staley and Moore, *Mobility First*.

175 Texas A&M Transportation Institute, *2012 Annual Urban Mobility Report*, p. 50.

[176] National Surface Transportation Policy and Study Revenue Committee, "National Traffic Signal Report Card," presentation made at The Atlanta Regional Traffic Operations Task Force, (Atlanta, GA March 17, 2005).

[177] Ibid.

[178] Although raised medians are often a principal element in access management, under heavy traffic conditions they can increase recurring congestion due to the limits on storage capacity of left-turn bays. Once these turn bays become full, additional left-turning traffic spills into the through lanes adding to delays. But because raised medians also increase safety by reducing the number of conflict points (thereby reducing accidents) they reduce incident-related congestion. When analysts crunch the numbers, they find a net decrease in congestion from the addition of raised medians, as the latter effect outweighs the former.

[179] Texas A&M Transportation Institute, *2012 Annual Urban Mobility Report*, p. 50.

[180] Iowa State University, *Access Management Frequently Asked Questions, Driveway Density and Driveway Consolidation*, (Ames, IA 2014), http://www.ctre.iastate.edu/research/access/toolkit/3.pdf

[181] United States Department of Transportation Federal Highway Administration, *Signalized Intersections An Informational Guide*, Chapter 2-2 Human Factors: Motorists, (Washington, DC 2013) http://safety.fhwa.dot.gov/intersection/signalized/13027/ch2.cfm.

[182] California State Assembly, Legislative Analyst's Office, Overview of Transportation Funding, (Sacramento, CA, March 13, 2014).

[183] Southern California Association of Governments, *2012 Regional Transportation Plan*, pp. 9–11.

[184] Ibid.

[185] "Traffic assignment" is a widely used method in transportation planning, in which future traffic on a proposed road is estimated by 'assigning' traffic from an assumed origin-destination pattern, such that traffic uses the fastest-time route, subject to traffic congestion. TransCAD© (www.caliper.com) is a widely available traffic assignment software package used by SCAG.

[186] This has the effect of slightly overestimating traffic, since the OD pairs used would be slightly high.

[187] K.L. Killough, "Value Analysis of Truck Toll Lanes in Southern California," paper presented at the Transportation Research Board, (Washington DC, 2007).

Kenneth Small et al., *Differentiated Road Pricing, Express Lanes and Carpools: Exploiting Heterogeneity Preferences in Policy Design*, (Washington D.C: Brookings Institute, 2006). This analysis, for the SR 91 express lanes in the nearby San Diego area, found a median value of time of $ 19.63/hour and a median value of reliability of $20.76/hour.

[188] United States Department of Transportation, Office of the Secretary, *Treatment of the Economic Value of a Statistical Life in a Departmental Analysis*, (Washington, DC Feb 2, 2008). The memo recommends a value of $ 5.8 M, from a range of $ 3.2-8.4 M. We used $5.8 M for this study. This is not, strictly speaking, the "value of a life" but rather the per-life cost of all traffic accidents including injuries and property-damage-only.

[189] Howard Slavin, *What TransCAD Users Should Know about New Static Traffic Assignment Methods*, (Caliper Corporation, May 14, 2010).

[190] U.S. Department of Energy, Energy Efficiency and Renewable Energy, *Compare Side by Side: Fuel Economy*, https://www.fueleconomy.gov/feg/Find.do?action=sbs&id=33324

[191] U.S. Department of Transportation Bureau of Transportation Statistics, Table 4-23: *Average Fuel Efficiency of U.S. Light Duty Vehicles*, (Washington, D.C.: USDOT, 2012), http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

[192] Brian Weatherford, *Mileage-Based User Fees Winners and Losers: An Analysis of the Distributional Implications of Taxing Vehicle Miles Traveled, with Projections, 2010–2030*, (Santa Monica, CA: RAND Corporation, 2012), http://www.rand.org/pubs/rgs_dissertations/SD295.html

[193] Oregon Department of Transportation, *Oregon Mileage Fee Concept and Road User Fee Pilot Program Preliminary Findings February 2013*, (Salem, OR, 2014), http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUCPilotPrelimFind_Feb13.pdf

[194] Oregon Department of Transportation, *Road User Fee Task Force, Item I RUCP Implementation Status Report,* (Salem, OR 2014), http://www.oregon.gov/ODOT/HWY/RUFPP/docs/Item%20I%20-%20RUCP%20Implementation%20Status%20Report.pdf

[195] Nick Vyas, “California Infrastructure Outlook,” presentation delivered at the California Sustainable Transportation Funding Workshop, (Glendale, CA, October 7, 2014).

[196] Southern California Association of Governments, *Transportation Finance, Mileage-Based User Fee*, (Los Angeles, CA 2014), http://transfin.scag.ca.gov/Pages/Mileage-Based-User-Fee.aspx

5737 Mesmer Ave.
Los Angeles, CA 90230
310-391-2245
reason.org