

SMART MOBILITY FRAMEWORK GUIDE

Caltrans

SMART MOBILITY FRAMEWORK GUIDE

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California Department of Transportation

Acknowledgement

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SMART MOBILITY INTRODUCTION AND GUIDE OVERVIEW

Introduction

Nearly a decade ago, Caltrans introduced smart mobility as an overall approach to respond to the State's interrelated challenges of mobility and sustainability. California's transportation system affects the strength of our state's economy, the well-being of our residents, the health of our natural environment, and the livability of our communities. As such, Caltrans and its partner transportation agencies must consider a wide variety of issues as they plan, build, and manage the transportation system. Making appropriate decisions in this context is challenging, and often requires new perspectives and approaches.

The Smart Mobility Framework was developed over a two-year period through a process that included stakeholder workshops and listening sessions involving more than 100 staff from Caltrans and other agencies. The resulting product, *Smart Mobility 2010: A Call to Action for the New Decade*, provided new concepts and tools to be used to incorporate smart mobility into all phases of transportation decisionmaking.

As originally defined in *Smart Mobility 2010*, "Smart Mobility moves people and freight while enhancing California's economic, environmental, and human resources by emphasizing convenient and safe multimodal travel, speed suitability, accessibility, management of the circulation network, and efficient use of land."

Since its introduction, Caltrans has adopted a variety of policies and plans consistent with and supportive of the Smart Mobility Framework. These include:

- A new Mission-Vision-Goals adopted by Caltrans in 2014, which calls on the Department to "Make long-lasting, smart mobility decisions that improve the environment, support a vibrant economy, and build communities, not sprawl."
- The Strategic Management Plan, released in 2015, which includes a set of performance metrics and targets, several of which are closely aligned with the Smart Mobility Framework.
- The California Transportation Plan 2040, released in 2016, which articulated the following vision: "California's transportation system is safe, sustainable, universally accessible, and globally competitive. It provides reliable and efficient mobility for people, goods, and services, while meeting the state's greenhouse gas emission reduction goals and preserving the unique character of California's communities."
- Caltrans' first statewide bicycle and pedestrian plan, *Toward an Active California: State Bicycle + Pedestrian Plan*, released in 2017.

Some components of the Smart Mobility Framework, such as complete streets, are now being implemented throughout the Department. However, the Smart Mobility Framework is broader than just complete streets and active transportation. The smart mobility principles touch on nearly every aspect of planning and project delivery, and remain highly relevant today. Many Caltrans staff have embraced these principles, but have expressed a need for guidance on how the principles can be applied in practice. This guide addresses that need by describing strategies, performance measures, and analysis methods for implementing smart mobility, organized around five themes: **network management, multimodal choices, speed suitability, accessibility and connectivity, and equity**. The guide also describes the application of place types to identify transportation planning and project development priorities across the state. Case study examples are used to illustrate the application of smart mobility strategies in real-world plans and projects, both within California and elsewhere in the U.S.

Who is this guide for?

This guide was primarily written for planners, engineers, and other transportation professionals who develop and maintain the state highway system and/or connected facilities. This guide is a starting point for those working to incorporate the Smart Mobility Framework into plans and projects.

Source: California Department of Transportation

Why the Need for Smart Mobility

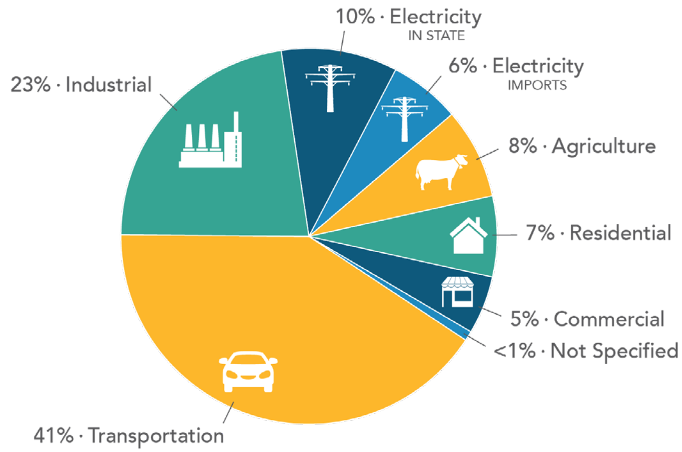
The development of the original Smart Mobility Framework commenced more than a decade ago in response to a number of trends and concerns, such as climate change, traffic congestion, and public health and safety, among others, as well as a growing recognition that the traditional approach to transportation planning and project development was ill-suited to meet the needs of Californians today. Ten years later, these concerns have grown in importance, and the need for the Smart Mobility Framework is greater than ever.

Source: California Department of Transportation

CLIMATE CHANGE

Climate change poses serious threats to California's transportation systems, natural resources, economy, and quality of life. The effects of climate change are now being experienced throughout California and the world, and will almost certainly grow worse in the coming decades. While state policies such as AB 32 and SB 32 are contributing to reductions in greenhouse gas (GHG) emissions, transportation remains the largest source of the State's emissions. Moreover, after declining over the period 2007-2013, transportation GHG emissions now appear to be increasing again, driven by growth in passenger vehicle activity. Much of the necessary GHG reductions in the transportation sector will come from clean vehicle technologies and low carbon fuels, but vehicle miles traveled (VMT) reductions will also be necessary to achieve the state's GHG reduction targets.

Figure 1: California GHG Emissions by Sector in 2017

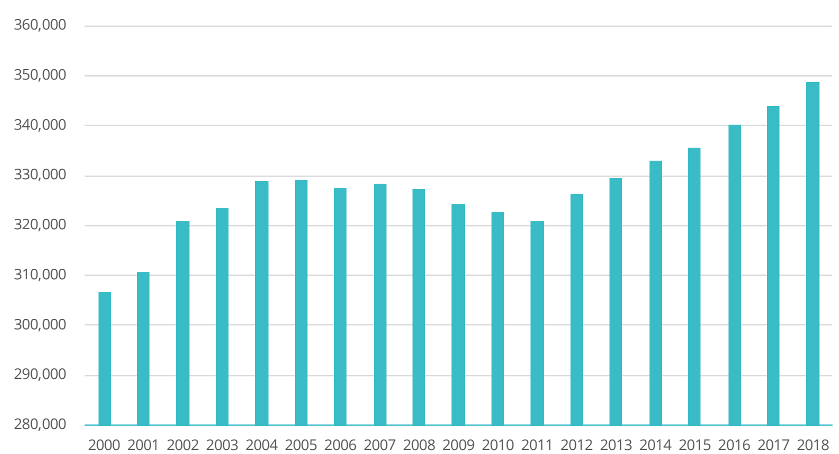


Source: California Air Resource Board, California Greenhouse Gas Emission Inventory - 2018 Edition

FOCUS ON VMT REDUCTION

Implementation of SB 743 places a new emphasis on reducing VMT and highlights the nexus between VMT reduction and the State's climate change goals. SB 743 mandated a change in the way that public agencies evaluate transportation impacts of projects under CEQA, focusing on VMT rather than level of service (LOS) and other delay-based metrics. As a result of this shift, agencies implementing both land use and transportation projects will need to better understand and prioritize strategies for reducing VMT. VMT reduction is also emphasized in the Caltrans Strategic Management Plan, which established a goal of reducing statewide per capita VMT by 15 percent relative to 2010 levels.

Figure 2: Average Annual California VMT in Millions

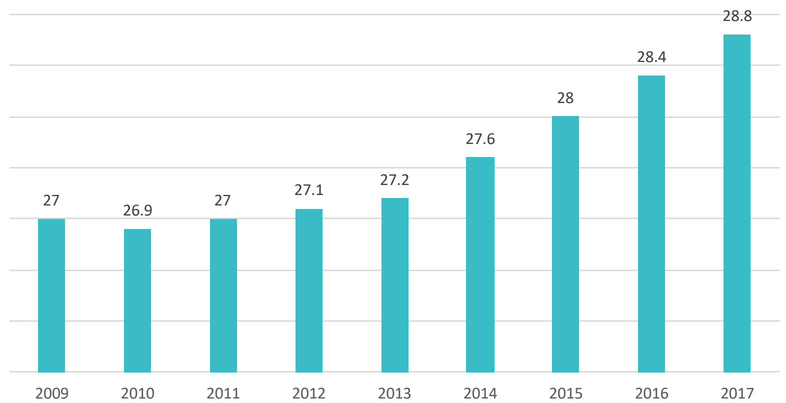


Source: FHWA Highway Statistics

CONGESTION AND VEHICLE TRAVEL

Vehicle travel and associated traffic congestion are on the rise. After declining during the Great Recession of 2008, VMT in California is again increasing, reaching the highest levels ever. Traffic congestion is among the worst in the nation. Vehicle hours of delay on the state highway system have doubled since 2011.[1] The rise in traffic congestion is particularly problematic in the state's major metropolitan areas. The Los Angeles metro area and the Bay Area rank number two and number three nationally for delay per automobile commuter.[2] Traffic congestion in these areas is significantly worse compared to previous economic booms, with delay growing much faster than population.[3]

Figure 3: California Commute Time in Minutes



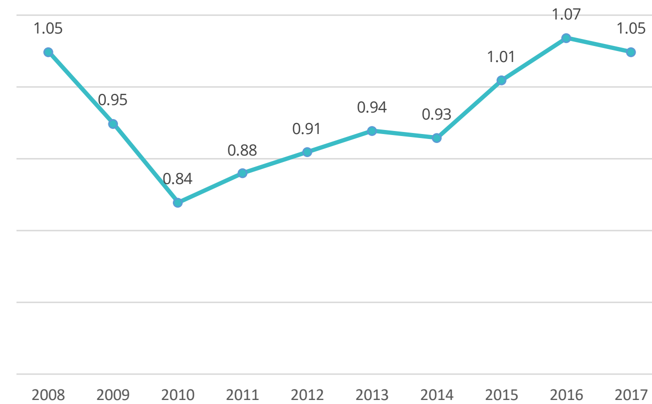
Source: U.S. Census

Source: California Department of Transportation

TRAFFIC SAFETY

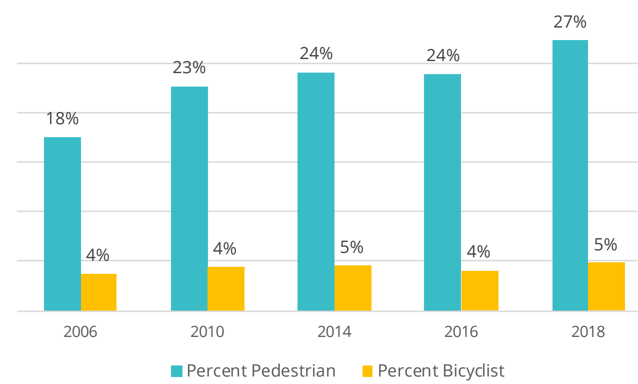
After reaching a historic low in 2010, the number and rate of traffic fatalities in California have been rising. As shown in Figure 4, the state's traffic fatality rate increased steadily between 2010 and 2016, recently dropping marginally in 2018. Traffic safety for pedestrians and bicyclists remains a particular concern. Over the last decade there were an average of 13 pedestrian fatalities and 2.5 bicycle fatalities every week in California.[4] Over one quarter of fatal crashes in California now involves a pedestrian, up from 18 percent in 2006.

Figure 4: Fatality Rate in California (per 100 million VMT)



Source: National Highway Traffic Safety Administration

Figure 5: Fatal Crashes Involving Pedestrians and Bicyclists as a Percentage of All Fatal Crashes in California



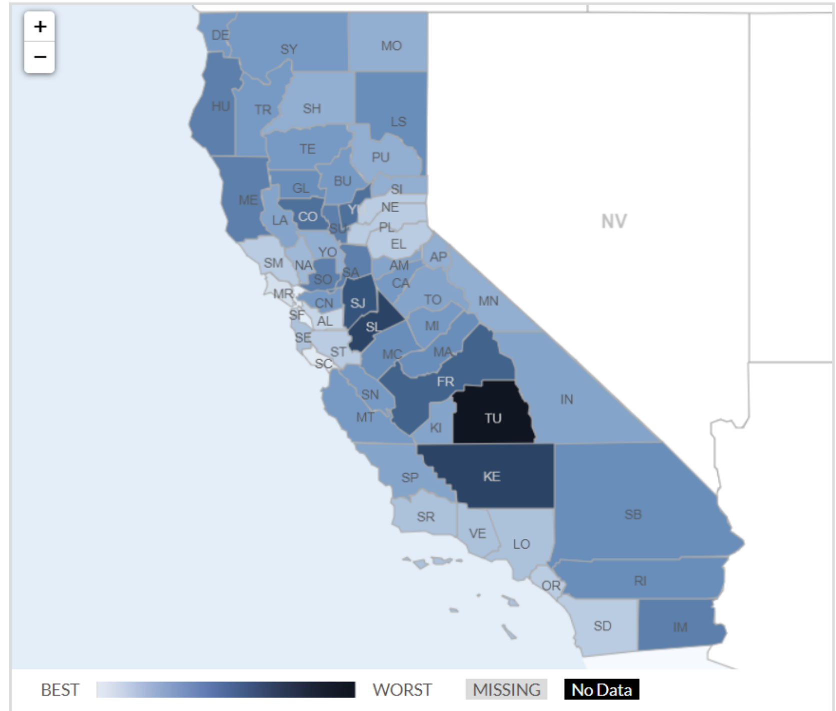
Source: National Highway Traffic Safety Administration

Source: California Department of Transportation

HOUSING AFFORDABILITY

Average housing prices in all counties in California have risen above 30 percent of average incomes, the traditional measure of affordability.[5] Transportation is typically the second highest household expenditure. In California, the majority of counties have a combined housing and transportation cost of more than 50 percent of household income.[6] Compact development patterns supported by a robust multimodal network can reduce transportation costs by increasing opportunities to connect residents to jobs, schools, recreation, commercial and retail centers, and other services.

Figure 6: Percent of Obesity Among Adults in California by County (Best=17%, Worst=23%).



Source: County Health Rankings & Roadmaps Program, Robert Wood Johnson Foundation

LACK OF PHYSICAL ACTIVITY AND RISING OBESITY

Despite the state's generally mild climate and reputation for active lifestyle, many Californians are sedentary. One in five California residents engages in no physical activity outside of work.[7] A lack of physical activity contributes to obesity and associated public health problems. More than 25 percent of adults and 14 percent of adolescents in California have are considered obese.[8] Obesity rates are higher in suburban and rural areas, where driving rates are the highest.

Smart Mobility Principles

Health and Safety: Design, operate, and manage the transportation system to reduce serious injuries and fatalities, promote active living, and lessen exposure to pollution.

Reliable Mobility: Manage, reduce, and avoid congestion by emphasizing multimodal options and network management through operational improvements and other strategies. Provide predictability and capacity increases focused on travel that supports economic productivity.

Environmental Stewardship: Protect and enhance the state's transportation system and its built and natural environment. Act to reduce the transportation system's emission of GHGs that contribute to global climate change.

Social Equity: Provide mobility for people who are economically, socially, or physically disadvantaged in order to support their full participation in society.Design and manage the transportation system in order to equitably distribute its benefits and burdens.

Robust Economy: Invest in transportation improvements – including operational improvements – that support the economic health of the state and local governments, the competitiveness of California's businesses, and the welfare of California residents.

Location Efficiency: Integrate transportation and land use in order to achieve high levels of non-motorized travel and transit use, reduced vehicle trip making, and shorter average trip length while providing a high level of accessibility.

Beneficial Technology: Use technology in the service of other smart mobility principles to increase transportation choices while respecting the other principles.

Smart Mobility Principles

The Smart Mobility Framework is founded on a set of core principles, first introduced in *Smart Mobility 2010* and expanded in this guide. These principles should steer actions to implement the Framework throughout planning, programming, and project development. The principles offer a more holistic and multimodal interpretation of what were traditional transportation agency goals for highway mobility, safety, and economic productivity. In addition to the six original Smart Mobility Framework principles, this guide introduces a seventh principle, recognizing the growing opportunities and challenges related to advanced transportation technologies.

HEALTH AND SAFETY

Design, operate, and manage the transportation system to reduce serious injuries and fatalities, promote active living, and lessen exposure to pollution.

Smart mobility improves public health and safety in multiple ways. Reducing the frequency and severity of vehicle crashes is one of Caltrans' top priorities. A smart mobility approach enhances these efforts while also focusing more attention on bicycle and pedestrian safety. Another opportunity to improve public health through transportation relates to encouraging physical activity. By improving bicycle and pedestrian facilities, transportation agencies create opportunities for people to exercise for recreation and to build physical activity into their daily routine. Transportation plans and projects can also improve public health by helping to reduce air pollution when they limit vehicle travel, particularly during peak periods when the highway system is most congested and vehicles operate in the least efficient, most polluting mode.

RELIABLE MOBILITY

Manage, reduce, and avoid congestion by emphasizing multimodal options and network management through operational improvements and other strategies. Provide predictability and capacity increases focused on travel that supports economic productivity.

Effective multimodal transportation systems enable people to reach destinations with consistent, predictable travel times. Transportation reliability refers to the variance in travel time – how much the travel time between two points can vary hour-to-hour, day-to-day, and week-to-week. The historic approach to address congestion was to expand roadway capacity, an approach that today may be prohibitively expensive and that has often proven ineffective due to induced vehicle travel. A smart mobility approach focuses on improving the reliability of the transportation system through both traditional system management strategies as well as managing the demand for vehicle travel. Transportation system reliability can be improved by providing convenient and efficient alternatives to driving.

ENVIRONMENTAL STEWARDSHIP

Protect and enhance the State's transportation system and its built and natural environment. Act to reduce the transportation system's emission of GHGs that contribute to global climate change.

Smart mobility advances environmental stewardship by minimizing the adverse impacts of vehicle travel and by designing and building transportation projects that enhance the natural and human environment. Climate change is the most pressing and potentially catastrophic environmental threat today. The *California Climate Change Scoping Plan* makes it clear that reducing VMT is essential to achieving the State's GHG reduction goals under the Global Warming Solutions Act of 2006. Smart mobility supports state, regional, and local efforts to reduce GHG emissions from personal vehicles. Transportation projects also contribute to environmental stewardship when they enhance and improve natural ecosystems and public places. A smart mobility approach seeks to go beyond mere compliance with environmental regulations that protect against damage. Transportation projects enhance the built environment by using context sensitive design.

ROBUST ECONOMY

Invest in transportation improvements – including operational improvements – that support the economic health of the state and local governments, the competitiveness of California's businesses, and the welfare of California residents.

Well-designed transportation investments contribute to the creation of livable communities and local economic development. Historically, the relationship between transportation and economic development has focused on the expansion of networks, improved mobility, and better access to jobs and markets. But now that our roadway networks are largely built-out, the economic benefit of additional capacity expansion is limited, and in some cases, merely shifts jobs from one part of the region to another.[9] A smart mobility approach focuses on using transportation investments to enhance regional competitiveness and local economic development by contributing to creative placemaking. A variety of research has shown that improving multimodal access, while reducing VMT or vehicle speeds, leads to benefits for residents, business, and local governments.[10] A smart mobility focus on multimodal transportation systems and less automobile reliance will help California's metropolitan areas remain competitive in attracting the creative and skilled workers needed to grow our economy.

SOCIAL EQUITY

Provide mobility for people who are economically, socially, or physically disadvantaged in order to support their full participation in society. Design and manage the transportation system in order to equitably distribute its benefits and burdens.

Smart mobility helps to increase opportunities for vulnerable and disadvantaged members of a community, including low-income residents, individuals with disabilities, children, and seniors. For example, households in low-income areas typically own fewer vehicles, have longer commutes, and have higher transportation costs. Improving pedestrian and bicycle infrastructure and increasing public transportation service in low-income communities can improve connectivity and improve access to jobs and essential services such as health care. Without available transportation, seniors may be forced to relocate due to poor access to local services. Older adults can "age in place" and require fewer supportive services if they can reach grocery stores and medical care independently.

LOCATION EFFICIENCY

Integrate transportation and land use in order to achieve high levels of non-motorized travel and transit use, reduced vehicle trip making, and shorter average trip length while providing a high level of accessibility.

Location efficiency describes the fit between a specific physical environment and its transportation system and services. Two sets of factors indicate the potential for achieving smart mobility benefits through location efficiency:

- **Community design** refers to characteristics of land use, urban form, and location that combine with the multimodal transportation system to support convenience, non-motorized travel, and efficient vehicle trips at the neighborhood and area scale.
- **Regional accessibility** refers to characteristics of land use, urban form, and location combined with the transportation system to make destinations available through non-single occupancy vehicle (SOV) travel and efficient vehicle trips at the regional, interstate, and international scales.

Location efficient community design elements include building and land use intensity, mixing of land uses, small blocks, and proximity to local-serving destinations such as parks, schools, retail, and services. Complementary transportation system elements include convenient, safe, and comfortable bicycle and pedestrian access, multimodal circulation network connectivity, and a well-connected complete streets system. Presence of these elements has repeatedly been shown to be associated with lower VMT, higher bicycle and pedestrian mode share, and lower GHG emissions per capita.[11]

Location efficient regional accessibility elements include an affordable housing supply near urban centers and other major employment centers as well as regional attractions in central and highly accessible locations. Complementary transportation system elements include a high level of multimodal system connectivity to other parts of the region and multimodal access to major destinations and intermodal terminals. Extensive research has also shown these elements can lower VMT per capita.

Independently, both community design and regional accessibility produce smart mobility benefits. However, the greatest potential to achieve location efficiency–and thus gain positive smart mobility outcomes–is when there is a strong presence of both community design and regional accessibility factors, as illustrated in Figure 7.

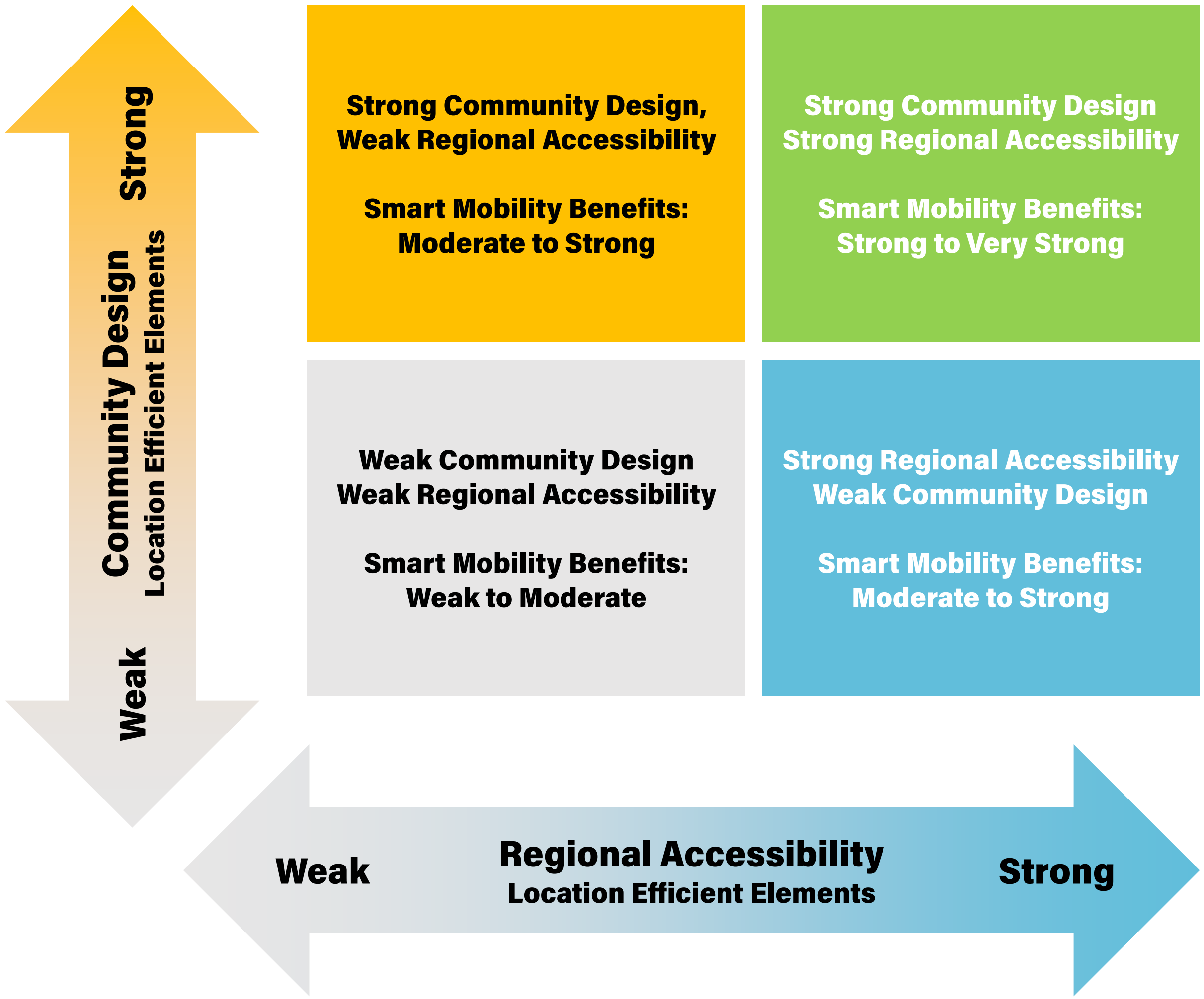
BENEFICIAL TECHNOLOGY

Use technology in the service of other smart mobility principles to increase transportation choices while respecting the other principles.

Technology has helped to increase travel choices, accelerated by sharing vehicles through car sharing programs and connecting riders with drivers through transportation network companies (TNCs) such as Uber and Lyft. The sharing concept has recently extended to bikes, e-bikes, and e-scooters, while private companies have also entered the transit market by offering demand-responsive service. The next evolution in mobility will be a transition to autonomous vehicles (AVs). Given these ongoing changes, the challenge for state and local agencies is to balance the increase in travel choices made possible by technology and sharing with other smart mobility principles, especially the desire to reduce VMT. Recent research has demonstrated that a large portion of TNC passengers represent new vehicle trips and new VMT, increasing overall VMT.

As TNC service transitions to driverless vehicles and AVs are made available for private use, the cost of vehicle travel in both time and money is projected to drop. With AVs reducing the cost of vehicle use and increasing the pool of potential vehicle users (i.e., those without licenses today), more vehicle travel is expected. Curbing potential increases in VMT to achieve smart mobility benefits will likely require government intervention to offset the lower cost and encourage vehicle sharing.

Figure 7: Regional Accessibility and Community Design



Smart Mobility Strategies Overview

Implementing the Smart Mobility Framework in practice involves the application of specific concepts, methods, and tactics at various points in the planning and project development process. These concepts, methods, and tactics – broadly termed "strategies" – help to operationalize the seven smart mobility principles. Some of these strategies are well-established at Caltrans and its partner agencies, while others reflect emerging best practices that may be less familiar. The smart mobility strategies can be organized into the following five categories, although it is recognized that many individual methods and tactics could fit under more than one category:

1. **Network Management** – Managing and avoiding congestion by emphasizing multimodal travel options and network management through operational strategies while minimizing induced vehicle travel.
2. **Multimodal Choices** – Providing a multimodal system that offers safe and convenient travel options for all users
3. **Speed Suitability** – Designing, operating, and maintaining the transportation system to achieve roadway speeds that reduce serious injuries and fatalities, including for the most vulnerable users
4. **Accessibility and Connectivity** – Achieving high levels of multimodal accessibility to destinations to improve livability and reduce VMT.
5. **Equity** –Seeking fairness in mobility and accessibility to meet the needs of all community members.

The following matrix illustrates how the five categories of strategies support the smart mobility principles.

Strategy Categories	Smart Mobility Principles: Health and Safety	Reliable Mobility	Environmental Stewardship	Social Equity	Robust Economy	Location Efficiency	Beneficial Technology
Network Management		X	X		X		X
Multimodal Choices	X	X			X	X	X
Speed Suitability	X			X			
Accessibility and Connectivity	X		X		X	X	X
Equity				X			X

The strategies can be used by transportation professionals in different contexts and at different stages of transportation decision making – primarily during planning and project development, but also potentially extending to maintenance and traffic operations. Each strategy described in this guide lists key applications for Caltrans and identifies the most appropriate phases in the transportation decision making process for applying the strategy. These phases are:

- **Planning.** Includes District System Management Plans (DSMPs), Corridor System Management Plans (CSMPs), corridor plans, Headquarters and District bicycle and pedestrian plans, the Interregional Transportation Strategic Plan (ITSP), and other system planning products.
- **Project Initiation.** Includes Project Initiation Documents (PIDs), Multimodal Operations Non-SHOPP Transportation Equity Report (MONSTER), State Highway Operation and Improvement Program (SHOPP), State Transportation Improvement Program (STIP), and other documents.
- **Project Development.** Includes the Draft Project Report (DPR), environmental studies, Plans, Specifications, and Estimate (PS&E), project design, and project construction.
- **Operations and Maintenance.** Includes traffic operations, maintenance of the highway system, and performance monitoring.

The following figure is included with each strategy to illustrate which phases are most relevant.

Each of the following strategy chapters includes:

- Overview of the strategy category
- Description of individual strategies
- Suggested performance measures that can be used to evaluate the strategy
- List of resources, such as design guides or policy documents
- Examples of applications

List of Commonly Used Acronyms in this Guide

- AV: Autonomous vehicle
- GHG: Greenhouse gas
- HOT: High occupancy toll
- HOV: High occupancy vehicle
- LOS: Level of service
- LTS: Level of traffic stress
- PMD: Personal mobility device
- SOV: Single occupancy vehicle
- TNC: Transportation network company
- TSMO: Transportation systems management and operations
- VMT: Vehicle miles traveled

1. NETWORK MANAGEMENT STRATEGIES

1. Network Management Strategies

1. EVALUATE VMT CHANGES RESULTING FROM CAPACITY EXPANSION PROJECTS
2. WRITE PROJECT PURPOSE AND NEED STATEMENTS TO INCORPORATE SMART MOBILITY PRINCIPLES
3. USE PERSON THROUGHPUT VS. VEHICLE THROUGHPUT
4. APPLY CONGESTION PRICING

About Network Management

Network management addresses the fundamentals of what public agencies want the transportation network to do. Caltrans and its local partners own, operate, and maintain transportation networks to provide access to destinations. The experience of network users is influenced by how the network is managed with respect to space allocation, modal preferences and priorities, property access, travel speeds, seat utilization, and other performance related objectives (e.g., emission reduction). Caltrans and its local partners can manage and avoid congestion by emphasizing multimodal operations and operational strategies while minimizing induced vehicle travel.

Transportation plans (e.g., general plan circulation elements, congestion management plans, transportation corridor plans) and individual projects that propose to modify the transportation network should demonstrate that they will result in more people being moved per vehicle and more travel options so that travelers have reliable travel choices when facing congestion. A key challenge of providing this outcome today is that travel demand and network supply are not easily balanced.

The transportation network (especially urban area freeways) has limited capacity (e.g., supply) that is overwhelmed by peak period demand that is not constrained by price signals or managed effectively through other mechanisms. As a result, most urban freeway users experience slow speeds and unreliable travel times, while some urban rail and bus riders experience crowding that can be severe enough that riders are not able to board the bus or train. This outcome is directly related to individual travel behavior and how the network is managed. The slow freeway speeds represent an equilibrium between demand and supply, wherein users are subject to extra travel time as a "toll" associated with traveling during peak times. The toll in this case is a "soft" payment of extra time (or delay) above the non-peak travel time. An alternative approach to network management could include a "hard" toll, a monetary toll that minimizes the potential for demand to exceed supply, thus preserving speeds closer to the speed limit.

Source: California Department of Transportation

Using Network Operations To Improve Mobility

Transportation agencies directly influence network operations through their management strategies. The selection of management strategies depends on the values and priorities of the government agencies responsible for operating the transportation network. They also depend on whether the management strategy is only temporary in nature, such as those applied during construction. Those transportation systems management and operations (TSMO) strategies typically available in California for long-term use include the following:

- Road weather management
- Traffic signal coordination
- Traveler information systems
- Ramp metering
- Congestion pricing
- Integrated corridor management
- Access management
- Traffic incident management
- Freeway service patrols

When needed, the list of strategies also includes work zone and special event management.

More complete information on TSMO strategies can be found at the following FHWA and Caltrans websites.

- https://ops.fhwa.dot.gov/tsmo/index.htm
- http://www.dot.ca.gov/trafficops/tsmo/

Matching strategies to specific problem areas of the network depends on the values and priorities of the government agencies responsible for operating the transportation network. Hence, some of the more effective strategies such as congestion pricing are not commonly implemented because affected agencies or communities have not found the trade-offs associated with faster or more reliable travel times to warrant implementation given their priorities.

Source: California Department of Transportation

Understanding Induced Vehicle Travel

Induced vehicle travel effects are important to consider directly in transportation network analysis because they have the potential to degrade the mobility benefits of a project and underestimate its VMT and emissions impacts.

Induced Vehicle Travel refers to the additional vehicle travel that occurs when the cost of roadway travel is reduced (i.e., as a result of a capacity expansion that reduces travel times).[12] Induced vehicle travel is often measured using vehicle miles traveled (VMT). Induced vehicle travel is a subset of all induced travel, which could include travel by non-vehicle modes (e.g., expansion of a transit system could induce additional transit travel). Induced vehicle travel is closely related to the concept of "latent demand," which refers to the travel that would occur if the price were lower (i.e., travel times were faster), or in other words, the travel that does not occur because price is high (i.e., travel times are slow).

To understand how capacity expansion increases VMT, it is useful to break down the components of how travelers respond to travel time reductions and under what time frames those responses occur.

Short-term responses to an increase in roadway capacity can include:

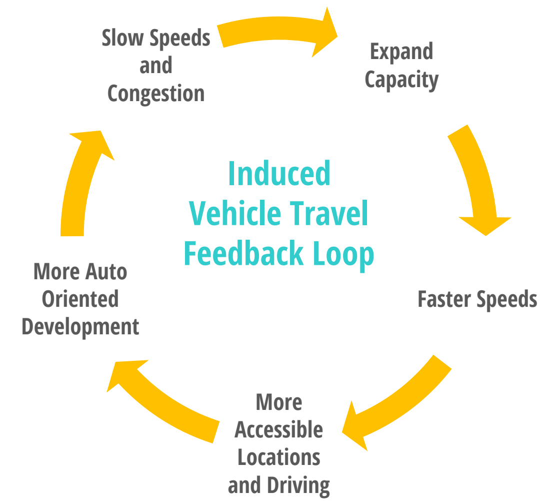
- New vehicle trips that would otherwise would not be made
- Longer vehicle trips to more distant destinations
- Shifts from other modes to driving
- Shifts from one driving route to another

Longer-term responses to an increase in roadway capacity can include:

- Changes in land use development patterns (typically a shift to more dispersed, low density patterns that are auto dependent)
- Changes in overall regional growth (the entire region might grow at a faster rate than would otherwise occur)

The longer-term responses are sometimes referred to as induced growth, which leads to induced travel. These longer-term responses are typically excluded in traffic forecasts for infrastructure projects. Traffic forecasts may also exclude short-term effects such as increased trip generation due to limited sensitivity in current travel forecasting models. In addition, researchers have defined induced investment to describe the phenomenon by which the increased vehicle traffic associated with highway investments leads public agencies to invest in projects that expand vehicle capacity.[13] This leads to a feedback loop that makes it difficult to solve congestion through roadway capacity expansion alone, as illustrated in Figure 8.

Figure 8: Induced Vehicle Travel Feedback Loop (Longer Term Response)



At a minimum, induced vehicle travel effects should be acknowledged and discussed for highway capacity expansion projects that will reduce travel times. Acknowledgment should disclose any limitations related to the forecasting that may have not been sensitive to induced vehicle travel effects and how those effects could influence the analysis results. This effort could include a qualitative discussion or even simple elasticity-based estimates of VMT derived from the project's lane mile changes. Disclosures should refer to the research findings on the subject presented in Table 1 or to the most recent and relevant research that becomes available. Consideration of induced vehicle travel may lead to different decisions regarding highway capacity expansion, and can highlight the need for alternative approaches including operational improvements and transportation demand management.

STRATEGY AT A GLANCE

1.1 EVALUATE VMT CHANGES RESULTING FROM CAPACITY EXPANSION PROJECTS

STRATEGY SUMMARY

- ❑ Consider VMT increases from induced travel related to roadway expansion projects.
- ❑ Estimate VMT changes from capacity expansion projects using elasticities of driving demand relative to roadway capacity.
- ❑ Use travel forecasting models to estimate induced VMT with caution. Models should be first tested to verify their sensitivity to both short-term and long-term induced vehicle travel effects.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- California Governor's Office of Planning and Research . Technical Advisory on Evaluating Transportation Impacts in CEQA
  http://opr.ca.gov/docs/20190122-743_Technical_Advisory.pdf
- Milam, Ronald T., Marc Birnbaum, Chris Ganson, Susan Handy, and Jerry Walters, "Closing the Induced Vehicle Travel Gap Between Research and Practice," Transportation Research Record: No. 2653
  https://journals.sagepub.com/doi/abs/10.3141/2653-02
- California Air Resources Board. Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief
  https://ww3.arb.ca.gov/cc/sb375/policies/hwycapacity/highway_capacity_brief.pdf

1.1 EVALUATE VMT CHANGES RESULTING FROM CAPACITY EXPANSION PROJECTS

To understand the magnitude of induced vehicle travel effects associated with capacity expansion projects, academic researchers have measured before and after conditions. Table 1 summarizes the research findings with regards to the relationship between the change in VMT and the change in capacity as measured by lane-miles.

The values in the right column of Table 1 can be considered "elasticities" because they relate the change in one variable (lane-miles) to a change in another variable (VMT). A value of 0.5, for example, implies that if a project increases lane miles by 20 percent, VMT will increase by 10 percent.

These elasticities can be used to generate direct estimates of VMT associated with capacity expansion projects as proposed in *Technical Advisory on Evaluating Transportation Impacts in CEQA*, from the California Governor's Office of Planning and Research. Figure 9 shows the individual steps involved in applying the elasticities to estimate a VMT change. This method can be used to estimate short-term and long-term VMT effects. An important consideration when using these elasticities is that they only produce 'positive' values when lane miles increase. Roadway capacity expansion projects such as new bridges that substantially reduce travel distances between origins and destinations will not be accurately represented. Also, only the short-term elasticities in the following table are appropriate for evaluating VMT effects from a travel forecasting model. That evaluation should focus on the differences between opening year no-build to opening year build conditions.

Table 1: Research on the Impact of Capacity Expansion on VMT

Study	Study Location (and Type)	Study Years	Time Period	Change in VMT / Change in Lane- Miles
Duranton and Turner (2009)	U.S. (metros)	1983-2003	10 years	1.03
Cervero (2003)	California (Freeway Corridors)	1980-1994	short-term long-term	0.10 0.39
Cervero and Hansen (2002)	California (Urban Counties)	1976-1997	short-term (1 year) Intermediate (5 years)	0.59 0.79
Noland (2001)	U.S. (States – all roadway types)	1984-1996	short-term long-term	0.30 to 0.60 0.70 to 1.00
Noland and Cowart (2000)	U.S. (Metro Areas – Freeways and arterials)	1982-1996	short-term long-term	0.28 0.90
Hansen and Huang (1997)	California (Metro Areas – State-owned highways)	1973-1990	short-term long-term counties long-term metro areas	0.20 0.60 to 0.70 0.90

Source: Handy, Susan and Marlon Boarnet, "Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions: Policy Brief," California Air Resources Board

Figure 9: Roadway Expansion Project VMT Estimation Method

To estimate VMT impacts from roadway expansion projects:

1. Determine the total lane-miles over an area that fully captures travel behavior changes resulting from the project (generally a county, multiple counties, or a region). The lane-mile data is available from the Highway Performance Monitoring System (HPMS).
2. Determine the percent change in total lane miles that will result from the project.
3. Determine the total existing VMT over that same area. This data is also available from HPMS.
4. Multiply the percent increase in lane miles by the existing VMT, then multiply that by the elasticity from the induced travel literature:
[% increase in lane miles] x [existing VMT] x [elasticity] = [VMT resulting from the project]

Source: Technical Advisory on Evaluating Transportation Impacts in CEQA. California Governor's Office of Planning and Research

An alternative approach is to rely on travel forecasting models to produce induced vehicle travel estimates, but only after those models have been tested to verify their sensitivity to both short-term and long-term induced vehicle travel effects. Data and modeling limitations need to be recognized and accounted for in the analytical process to avoid underestimates of induced vehicle travel effects. If a travel forecasting model is found to have limitations related to one or more of the induced vehicle travel components above, corrective actions can be taken to compensate for the limitation.

Depending on project circumstances, the corrective actions to account for model limitations may involve a qualitative or quantitative response. Project circumstances include the type of project, analysis purpose (alternatives analysis, design, or environmental impact analysis), resources, schedule, and level of controversy. Qualitative responses typically acknowledge the limitations of the forecasting method with respect to induced travel effects and describe how this limitation may have influenced any related analysis. Quantitative methods range from using off-model processes to compensate for model limitations, such as using the elasticity method above, to modifying the model to incorporate features necessary to adequately address the induced travel effects. When making a decision about the appropriate method, analysts should be aware of the expectations established in technical guidelines and environmental case law. In the future, Caltrans Standard Environmental Reference will be updated with VMT-related methodologies for projects on the State Highway System.

In general, almost all the induced vehicle travel effect can be accounted for by using advanced travel forecasting models that account for the feedback effects of travel time (or travel cost) savings on travel behavior and long-term land use allocation. The most advanced models have feedback loops that influence land use allocation, trip generation, trip distribution, mode choice, and route choice. Most local and regional models currently used in California do not include full feedback to land use or trip generation. Failure to account for the feedback effects will result in underestimating induced vehicle travel effects. Nevertheless, it is not always possible, feasible, or desirable to fully and appropriately apply advanced models for every transportation analysis.

In addition to highway capacity expansion with general purpose lanes, proper consideration of induced vehicle travel also applies to high-occupancy vehicle (HOV) and express lane projects. An HOV lane, also known as a carpool or diamond lane, is generally limited to motorcycles, buses, certain low-emission vehicles, and vehicles with two or more (2+) occupants during operational hours; in a few California locations, vehicles must have 3+ occupants to use the HOV lane. Express lanes are HOV lanes that allow single-occupancy vehicles to use the facility by paying a toll. Nearly all new California highway expansion projects today involve HOV or express lanes.

HOV and express lanes are often justified on the basis of increasing person throughput, reducing congestion, and reducing emissions. However, a variety of research suggests that these justifications deserve more scrutiny. By adding capacity, HOV and express lanes induce new vehicle travel in urbanized areas as described above. The additional VMT will at least partially offset any emissions benefits resulting from smoother traffic flow, and in some cases may completely offset these emissions benefits. In addition, the impact of HOV lane additions on carpool formation and average vehicle occupancy is uncertain. Before and after observations of HOV lane additions in the 1990s suggest the facilities did increase average vehicle occupancy. However, other research suggests that any travel time savings offered by an HOV lane is often not significant enough to cause drivers to form new carpools, particularly given that carpooling has declined significantly in recent years and that workplaces have become more spatially dispersed.[14]

For HOV lanes to effectively encourage carpooling, they must offer a significant travel time savings and better reliability as compared to general purpose lanes. Currently more than half of HOV lanes in the state exhibit "degraded" performance, defined as having average traffic speed during the morning or evening weekday peak commute hour is less than 45 miles per hour for more than 10 percent of the time.[15] Improving HOV lane performance though better enforcement and potentially higher occupancy requirements (e.g., 3+ occupants) can help to maximize their potential to boost ridesharing. HOV lanes are most effective when they carry large numbers of transit buses and vanpools; in these cases, the passenger throughput of the HOV lane can be significantly higher than general purpose lanes.

Source: California Department of Transportation

STRATEGY AT A GLANCE

1.2 WRITE PROJECT PURPOSE AND NEED STATEMENTS TO INCORPORATE SMART MOBILITY PRINCIPLES

STRATEGY SUMMARY

When writing the Purpose and Need Statement:

- ❑ Incorporate root or core problems, such as person throughput or accessibility
- ❑ Consider possible strategies related to the problem statement to test if they really address the core problem.
- ❑ Write a purpose and need statement that addresses core issues, based on considerations above.

WHERE IN THE PROCESS TO APPLY

1.2 WRITE PROJECT PURPOSE AND NEED STATEMENTS TO INCORPORATE SMART MOBILITY PRINCIPLES

The start of any analysis to measure transportation network performance must begin with a clear understanding of the analysis purpose and clear definition of the problem and its causes. Network analysis is a common component of transportation planning, design, and environmental impact studies. The word "congestion" is often used to describe today's roadway network problems. The specific words and metrics used in transportation analysis are very important to the decisionmaking process about how to solve identified problems. When describing a roadway as congested, participants in the analysis process will usually envision cars moving slowly on a freeway or stuck in queue. If this is the problem, then solutions will likely be focused on trying to increase speeds (i.e., treating the symptom). The actual cause of the problem, mispriced freeway travel and lack of alternatives, will not be identified. Further, solutions that focus on increasing speeds usually involve expanding roadway capacity. As demonstrated through induced vehicle travel research, these types of solutions in congested urban areas typically do not result in faster speeds after implementation. Instead, new vehicle trips are induced, and the added capacity is quickly absorbed such that speeds and travel times return to their previous levels. More cars can be served during the peak period due to the new capacity, which may be a benefit, but congestion was not relieved because drivers continue to experience the same travel time delays and slow speeds.

Environmental review and project scoping for transportation projects begins with a statement of the project "Purpose and Need." The Purpose and Need statement should be carefully considered as part of a smart mobility approach because it influences how the proposed project will be evaluated and what solutions will be considered. To emphasize the key points above, consider how a purpose and need statement would be affected by the slight difference in analysis methods and performance measures described in the two options below.

- **Problem Definition 1** – Existing traffic operations are congested with peak period operating speeds below the posted speed for up to two hours each morning and evening.

- **Problem Definition 2** – Existing traffic operations are congested with peak period operating speeds below the posted speed for up to two hours each morning and evening and seat utilization less than 35 percent during both periods.

While the differences in the problem definition may seem subtle, they would influence the project purpose objectives as follows:

- **Purpose 1** – The proposed action will achieve the following objectives: Add roadway capacity that reduces the total amount of a.m. and p.m. peak period travel below posted speeds.
- **Purpose 2** – The proposed action will achieve the following objectives: Reduce the total amount of a.m. and p.m. peak period travel below posted speeds by increasing seat utilization, or number of occupied seats in each vehicle.

These objectives would then influence the types of project alternatives. Under Purpose 1, project alternatives would be focused on increasing capacity to increase speeds and reduce vehicle delay. With Purpose 2, an expanded menu of TSMO strategies could be considered to improve vehicle occupancies such as managed lanes, pricing, and new travel modes. These strategies are also effective at managing induced vehicle travel effects that occur when travel costs (i.e., travel times) are lowered through network modifications such as capacity increases.

STRATEGY AT A GLANCE

1.3 USE PERSON THROUGHPUT VS. VEHICLE THROUGHPUT

STRATEGY SUMMARY

- ❑ Rather than using vehicle delay or standard LOS metrics, identify destinations within a corridor or project area, modes used to reach those destinations, and how those modal choices impact person throughput.
- ❑ Prioritize modes that demonstrate the greatest space efficiency (the amount of space required to transport a single person).

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- NACTO Transit Street Design Guide
  https://nacto.org/publication/urban-street-design-guide/
- NCHRP 08-36, Task 102: Assessing Alternative Methods for Measuring Regional Mobility in Metropolitan Regions
  http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(102)_FR.pdf

1.3 USE PERSON THROUGHPUT VS. VEHICLE THROUGHPUT

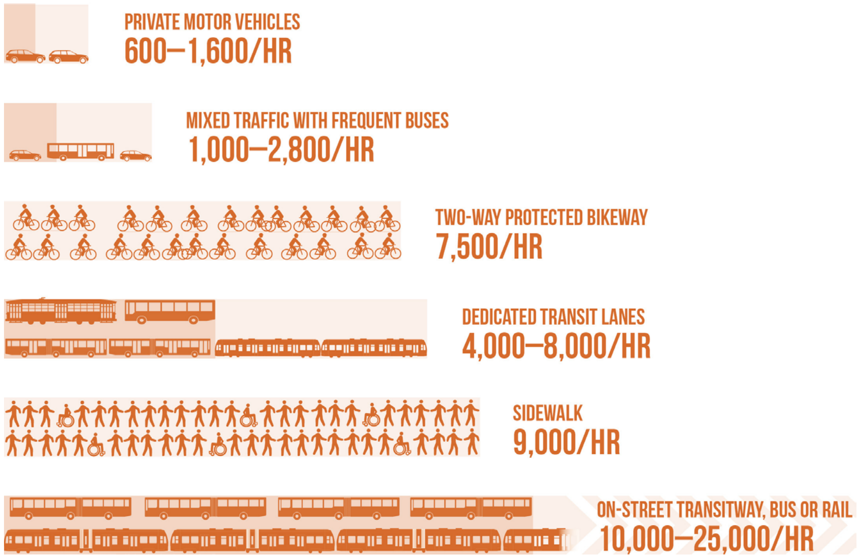
A key part of network management is to understand the relationship between land use context (i.e., place types), travel demand, growth patterns, and network space efficiency. As land use density increases so does the concentration of people associated with the land uses. Today, the built-out portions of cities are attracting more people due to employment opportunities and the concentration of other desired destinations. In simple terms, cities are becoming more populated. The growing population extends to the transportation network where roadways, transit vehicles, bike lanes, and sidewalks are full during peak periods. But with proper network management that takes space efficiency into account, a dense population does not have to feel crowded.

One of the key benefits of transit and active transportation is efficient space utilization, especially when compared to private auto use. The physical space consumed by each mode influences how many people the mode can transport, so network optimization should strive to prioritize those modes with the greatest space efficiency as density and crowding increase.

Efficient space allocation for the transportation network directly influences the number of persons it can serve. Figure 10 provides estimates of person throughput per hour for a single 10-foot travel lane under different modal allocations.

Recognizing the relationship between space and person throughput is important when selecting specific performance measures for transportation network analysis. Analysis that relies exclusively on metrics such as vehicle level-of-service (LOS) tends to ignore spatial relationships. Since LOS measures driver comfort and convenience based on metrics such as vehicle delay, solutions to fix LOS problems tend to focus on increasing roadway capacity for vehicles.

Figure 10: Person Throughput Comparison by Mode



Source: National Association of City Transportation Officials (NACTO) Transit Street Design Guide.

A more comprehensive understanding of the problem starts with identifying the desired destinations within the study area or corridor, what modes are being used to access those destinations, and how the modal choices influence network space utilization and travel time. Substantial increases in existing person throughput can often be achieved by using network space more efficiently, as shown in the figure above. Space efficiency gains can also occur through TSMO actions such as pricing, which result in more reliable and shorter travel times, albeit with a tax on driving.

STRATEGY AT A GLANCE

1.4 APPLY CONGESTION PRICING

STRATEGY SUMMARY

- ❑ Consider implementing congestion pricing to reduce driving demand, especially at peak periods.
- ❑ High occupancy vehicle (HOV) lanes may be good candidates for conversion into congestion pricing lanes.
- ❑ Allocate revenue from congestion pricing to alternative transportation options to increase multimodal choices and address equity concerns

WHERE IN THE PROCESS TO APPLY

RESOURCES

- California State Transportation Agency. California Transportation Infrastructure Priorities White Paper: Tolling and Pricing for Congestion Management and Transportation Infrastructure Funding https://calsta.ca.gov/-/media/calsta-media/documents/f0005371-docs-pdfs-2015-agency-ctip-pricingwhitepaper01122015.pdf
- TransForm, Pricing Roads, Advancing Equity www.transformca.org/transform-report/pricing-roads-advancing-equity

1.4 APPLY CONGESTION PRICING

Congestion pricing is recognized as one of the most effective TSMO strategies but also one of the most difficult to implement due to the trade-offs associated with changing the status quo. Congestion pricing involves motorist charges (tolls) that vary based on the level of vehicle demand on a highway facility.[16] Charges may vary by time of day (static) or according to real-time conditions on the facility.

Also known as value pricing or variable pricing, congestion pricing recognizes that trips have different values at different times and places and for different individuals. When drivers face premium charges during periods of peak demand, they are encouraged to eliminate lower-value trips, take them at a different time, or choose alternative routes or transport modes where available. If congestion pricing is applied only to specific traffic lanes rather than to an entire highway facility, users have the option of choosing to pay to use congestion-free priced lanes or continue to travel on general purpose lanes without paying a toll.

One potential problem with pricing strategies is that they may price some travelers "out of the market" without always providing effective alternatives to driving during peak periods. Those priced out are also those with the least ability to afford a new tax. Hence, the benefits of this approach tend to accrue to higher income travelers while the impact and loss of driving freedom are more likely to affect lower income travelers unless the government agency imposing the tax effectively compensates those priced out of the travel market with competitive alternatives for peak period travel. Some of these concerns can be addressed by using the pricing revenue to create alternative travel options for those willing to forgo peak-period vehicle travel. If not structured carefully, congestion pricing also has the potential to cause spillover effects whereby traffic is diverted to non-priced roadways in the same corridor.

While many questions may exist about how to define and to implement pricing, the absence of pricing (or other effective demand management strategies) clearly contributes to inefficient use of the existing network if measured based on vehicle occupancy or seat utilization. Average vehicle occupancy during peak periods is routinely measured at 1.15 persons per vehicle or lower.[17] This equates to seat utilization estimates of less than 35 percent during peak period conditions, which means that over 65 percent of the seats during the peak are empty.

The U.S. suffers from roadway congestion (i.e., slow moving vehicles) in part because the combination of public and private sector incentives and disincentives for travel fails to fill existing seats. This is in sharp contrast to U.S. passenger air travel, which benefits from a competitive and priced market, where planes operate with equivalent seat utilizations over 80 percent. The lack of a market for vehicle travel and associated roadway pricing is directly related to this outcome.

Potential strategies for implementing congestion pricing range from incremental projects such as converting an HOV lane to a high occupancy toll (HOT) lane to implementing systemwide programs such as a VMT tax with peak period dynamic pricing. The potential need to replace the gas tax revenue system may create an opportunity to pursue the latter option in a more robust way. This potential need is being evaluated by major metropolitan planning organizations (MPOs) in California as part of regional transportation plan/sustainable communities strategy (RTP/SCS) updates. The evaluation has been motivated in part by the potential loss of future gas tax revenue as well as the need to meet air quality and GHG reduction goals.

Example: Wasatch Front Central Corridor Study

> CASE STUDY AT A GLANCE

STRATEGIES

Use Person Throughput Vs Vehicle Throughput

KEY TAKEAWAYS

- Using metrics such as "increase person throughput" and "seat utilization" to evaluate alternatives for a corridor study can help planners identify design and programming solutions that will reduce congestion and avoid induced travel demand.

RESOURCES

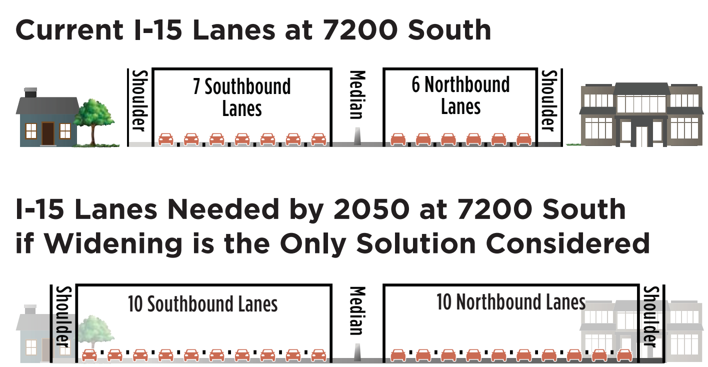
- Utah DOT, Utah Transit Authority, Mountainland Association of Governments, and the Wasatch Front Regional Council. Wasatch Front Central Corridor Study. http://wfccstudy.org/

The *Wasatch Front Central Corridor Study* (WFCCS) was conducted in the Salt Lake City metropolitan area in 2016 to address transportation needs for a rapidly growing population. The study started with the recognition that conventional vehicle-focused transportation analysis would not produce meaningful outcomes for the Interstate 15 (I-15) corridor given the physical and environmental constraints associated with simply expanding roadway capacity.

The analysis approach and selection of performance measures followed the Smart Mobility Framework. Three unique scenarios were developed to capture a diverse selection of solutions to address the travels demands of the region through 2050. Ten metrics were selected including 'increase person throughput', 'reduce household transportation costs', 'improve travel time reliability', 'seat utilization', and 'increase accessibility to jobs & education'. The use of these diverse metrics defined the problem of future growth on travel demand using multiple perspectives, which in turn produced solutions that combined a variety of supply-side and demand-side (e.g., pricing) strategies. This approach painted a comprehensive picture of scenario performance especially with regard to how travel demand by mode was related to the efficiency of that mode in moving people. Further, the inclusion of origin-destination travel time comparisons was effective in demonstrating that congestion could only be reduced through the travel pricing mechanisms included in Scenario 2. This was the only scenario that reduced travel times to below base year conditions. Expanding roadway capacity in the other scenarios could only lessen the increase in congestion in part due to induced vehicle travel effects.

The WFCCS approach tested three scenarios along the spectrum of more demand management to more supply/capacity expansion. This allowed results for each metric to be evaluated against whether demand management or supply expansion had a better outcome. In general, the best scenario involved optimizing the transportation network utilization through variable freeway pricing, expanding transit, and incentivizing transit use. This scenario not only improved existing seat utilization in the corridor but also provided the best improvement in travel times and reliability.

Figure 11: Illustration of Lanes Needed if Only Highway Widening Solution Considered



Source: Wasatch Front Central Corridor Study

Example: VicRoads HOV Lanes

> CASE STUDY AT A GLANCE

STRATEGIES

Use Person Throughout Vs Vehicle Throughput

KEY TAKEAWAYS

- Providing carpool and transit prioritized metered access to highways at on and off ramps encourages HOV use without requiring high occupancy vehicles to merge through several lanes of traffic for the benefit of a faster lane.

RESOURCES

- VicRoads Managed Motorways website https://www.vicroads.vic.gov.au/traffic-and-road-use/traffic-management/managed-motorways

VicRoads, the highway agency for the State of Victoria in Australia, has demonstrated an alternative approach to network management that is now being considered in the United States. VicRoads' Managed Motorways approach to HOV lanes is to provide transit and carpools with prioritized metered access to the freeway, and then optimize the performance of the freeway lanes for all users to provide reliable travel times. Single-occupancy vehicles are given lower priority for freeway access. Bypass lanes can also be used to improve freeway access for trucks. In California, the Contra Costa County Transportation Authority and Caltrans District 4 are evaluating this new program to better understand freeway management.

This approach reduces weaving conflicts because vehicles are not forced to move across four or five lanes to access the HOV lane and then return across the same lanes to exit the freeway. The Managed Motorways approach relies on the natural loading of the freeway lanes where short trips tend to stay right, and long trips move left towards the center lanes. To analyze whether HOV lanes will be effective at achieving the desired outcomes listed above, the analysis needs to use travel demand models containing dynamic traffic assignment (DTA) methods which are integrated with multimodal microsimulation traffic operations models. These models will capture the full range of HOV lane effects so that potential project outcomes are not misrepresented.

Figure 12: HOV Lane in Victoria Australia

Source: VicRoads (Victoria, Australia)

2.MULTIMODAL STRATEGIES

2. Multimodal Strategies

1. PROVIDE PEDESTRIAN FACILITIES
2. PROVIDE BICYCLE FACILITIES
3. CONDUCT BICYCLE AND PEDESTRIAN COUNTS
4. CONDUCT BICYCLE LEVEL OF STRESS ANALYSIS
5. IMPROVE TRANSIT AND CONNECTIONS TO TRANSIT
6. MANAGE CURB SPACE TO ACCOMMODATE NEW MODES & ACTIVITY

About Multimodal Choices

Multimodal choice, a core tenet of the smart mobility framework, involves the provision of safe and convenient facilities for walking, bicycling, and transit for all users. Walking and bicycling for transportation can improve health by promoting physical activity, serve as an important means of access for persons with disabilities, and reduce air pollution and GHG emissions by avoiding vehicular travel. The *Caltrans Strategic Management Plan* has set a goal to increase the number of complete streets projects by 20 percent between 2010 and 2020. This plan also sets goals to double the rate of walking and transit trips and triple the rate of bicycling between 2010 and 2020. Transit serves as a lifeline for many people–especially those without access to a vehicle–to reach jobs, healthcare, and other destinations. New mobility modes, such as personal mobility devices (PMDs) and ridehailing/ridesharing services, can also meet the transportation needs of many people, especially in urban areas.

Providing a multimodal transportation system supports Caltrans goal of "Toward Zero Deaths", identified in the *California Strategic Highway Safety Plan 2015-2019*. A robust network of appropriate bicycle and pedestrian facilities, along with a strong transit system, facilitates safer options for all. On the path to achieving zero deaths on the California road network, the plan sets goals of annual 3 and 1.5 percent reductions in both the number and rate of fatalities and severe injuries, respectively.[18] "Towards Zero Deaths" aligns with the Vision Zero movement adopted by cities across the world, which strives to eliminate all traffic related fatalities through infrastructure, signage, and policy strategies. Multimodal improvements can also support the smart mobility Social Equity principle. Nationwide, pedestrian fatalities are more likely to occur among people of color and in lower-income communities.[19]

There is no acceptable number of traffic-related fatalities. Behavior and environmental factors can each play a role in traffic-related injuries and fatalities, and strategies to address both behavioral and environmental risks are required to eliminate collisions. Studies have shown that bicycle and pedestrian facilities separated from vehicular traffic are linked to reductions in injuries.[20] Caltrans can develop infrastructure to decrease traffic speeds, improve visibility, and where appropriate, separate modes to reduce risks.

Multimodal transportation options also support public health by promoting active transportation. Bicycle and pedestrian facilities create opportunities for people to exercise, which can help reduce obesity and the risks for developing costly chronic conditions such as diabetes and cardiovascular disease. A variety of research has shown a clear relationship between the built environment, physical activity, and associated health outcomes.[21,22]

Source: California Department of Transportation

Caltrans helps to encourage multimodal choices through its Complete Streets program. "Complete Streets" is a concept that describes designing streets for people using all modes. A complete street accommodates persons of all ages and abilities walking, bicycling, using transit, and driving. Complete streets designs vary based on the context of the street and needs of users.

Many complete street facilities and elements, such as bike lanes and high visibility crosswalks, can be incorporated into traditional roadway infrastructure projects. Caltrans' State Highway Operation and Protection Program (SHOPP) tool now includes complete street facilities, which can be added to projects as appropriate. Caltrans provides a Complete Streets Elements Toolbox to help planners add complete street elements to projects. The Toolbox includes descriptions of roadway elements along with their corresponding ID in the SHOPP tool and unit of measurement. In addition, the Toolbox includes numerous real-world examples and links to key reference documents.

Not all infrastructure elements to support walking and bicycling are appropriate on all roadways. This section describes selected elements that can be included on roadways to promote multimodal choices in appropriate contexts. When designing accommodations for walking and bicycling, designers should consider how users will travel both along and across the roadways, and any gaps in the network. Gaps in the network can be significant barriers to walking and bicycling and should be addressed to allow users to travel freely.

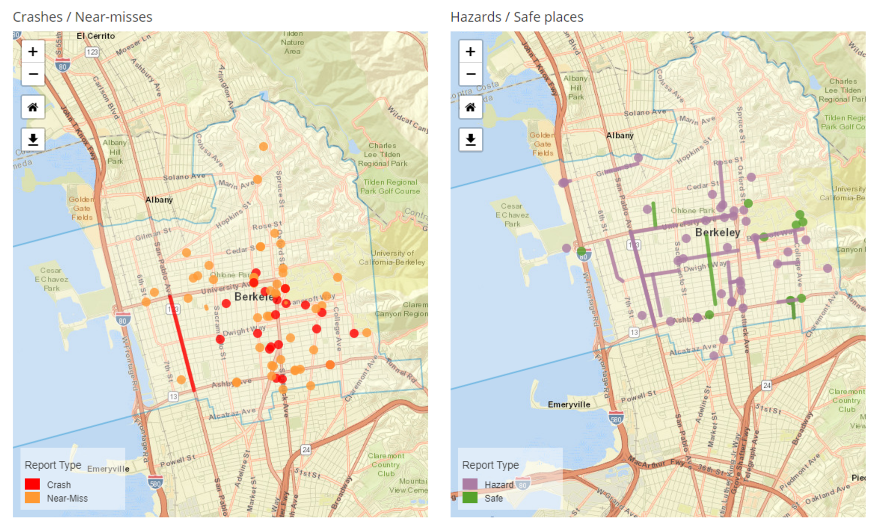
Evaluating the Comfort, Quality, and Safety of Bicycle/Pedestrian Network

For a neighborhood or city to truly accommodate walking and bicycling, a safe, comfortable, and connected network must be in place. Streets and larger areas can be assessed for bicyclist safety and comfort in a variety of ways. Planners can measure the numbers of people walking and bicycling on a particular segment or area, changes in bicyclist and pedestrian crashes, or conduct a bicycle level of stress analysis, which analyzes the type of bicycle facilities and the greater context of the street where they are located. Planners can also conduct walk audits to evaluate specific issues in particular areas. Walk audits can be a good tool to invite community input and participation, as well as online public mapping tools to collect data on facility safety, quality, demand, proposed projects, or other questions requiring public input.

The Berkeley Safe Transportation Research and Education Center (SafeTREC) provides tools and resources to assist planners with multimodal analyses, including, but not limited to:

- CA Active Transportation Safety Information Pages (CATSIP),
- Transportation Injury Mapping System (TIMS), which has geo-coded California crash data
- Streetstory online public engagement mapping software

Figure 13: Sample Streetstory for Berkeley



Source: SafeTREC

STRATEGY AT A GLANCE

2.1 PROVIDE PEDESTRIAN FACILITIES

STRATEGY SUMMARY

- ❑ Use performance measures for pedestrian access and safety when developing corridor plans. Performance measures can include mode share, pedestrian counts, and pedestrian injuries.
- ❑ Include pedestrian accommodations or facilities in a project using the SHOPP tool. Pedestrian facilities can be added as part of an existing project or during resurfacing.
- ❑ Consider new facility designs approved by Caltrans or FHWA, such as pedestrian hybrid beacons, which can improve pedestrian safety and comfort in specific contexts.

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- Caltrans Complete Streets SHOPP Tool
- NACTO Urban Street Design Guide
  https://nacto.org/publication/urban-street-design-guide/
- FHWA Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/
- FHWA Small Town and Rural Multimodal Networks Design Guide
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf
- FHWA PedSafe/Bike Safe Countermeasures
  http://www.pedbikesafe.org/
- Main Street, California
  https://dot.ca.gov/-/media/dot-media/programs/design/documents/main-street-3rd-edition-a11y.pdf

2.1 PROVIDE PEDESTRIAN FACILITIES

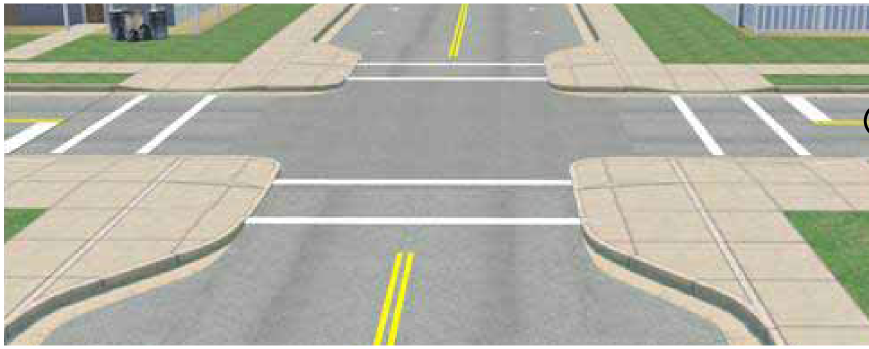
Pedestrians traveling along roadways require some form of separation from vehicles for safety and comfort purposes. Generally speaking, as traffic volumes and speeds increase, the separation of pedestrian facilities should also increase for pedestrian safety and comfort. Decorative buffers, planting strips, and even parking lanes create separation from traffic.

Crosswalks facilitate safe and comfortable pedestrian crossings at intersections or other areas along a road where appropriate. While a pedestrian has the right to cross the street at any intersection (unless specifically prohibited by law), regardless of whether or not it is marked, crosswalk markings and other infrastructure can improve the visibility of the crosswalk. Infrastructure can also help reduce vehicle speed around crosswalks and provide comfortable spaces for pedestrians to wait as they cross the street. Some infrastructure amenities to support safe pedestrian crossings are as follows. Pedestrian infrastructure should always be designed according to the Americans with Disabilities Act (ADA) standards.

Source: California Department of Transportation

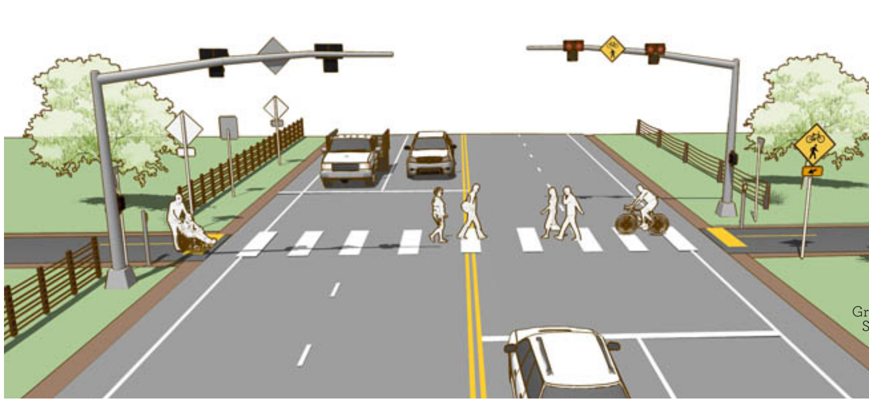
The Caltrans Complete Streets Elements Toolbox includes typical pedestrian accommodations, many of which can be added to a project using the SHOPP tool. Examples are shown in Figure 14 and Figure 15.

Figure 14: Bulb-out



Source: FHWA Simulator Evaluation of Low-Cost Safety Improvements on Rural Two-Lane Undivided Roads: Nighttime Delineation for Curves and Traffic Calming for Small Towns

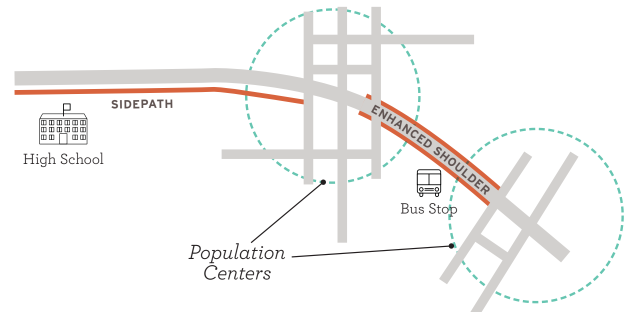
Figure 15: Pedestrian Hybrid Beacon



Source: FHWA Small Town and Rural Multimodal Networks

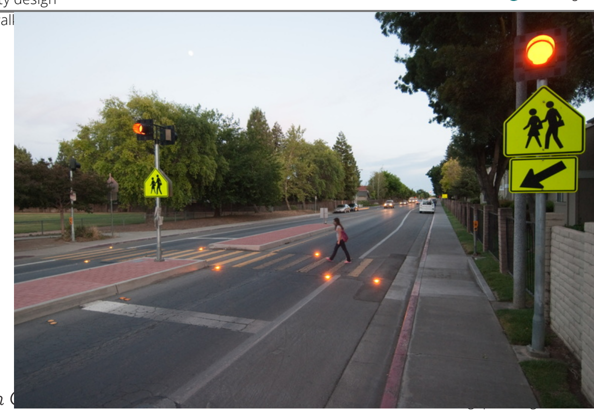
In small towns and rural areas, the provision of pedestrian facilities may require a different approach compared to urban areas. One option is to use sidepaths and enhanced shoulders to improve accessibility in rural areas or small towns. As noted earlier, higher speed and higher volume roads typically warrant greater separation between vehicle and pedestrian traffic. Figure 16 illustrates a potential design concept for a rural area with two small population centers and a school. A sidepath creates more separation from traffic than an enhanced shoulder, adding more protection for vulnerable users.

Figure 16: Pedestrian (and Bicycle) Connection Considerations in Rural Areas



Source: FHWA Small Town and Rural Multimodal Networks

Figure 17: Pedestrian Crosswalk with Light



Source: California Department of Transportation - Photo Gallery

STRATEGY AT A GLANCE

2.2 PROVIDE BICYCLE FACILITIES

STRATEGY SUMMARY

- ❑ Use performance measures for bicycle access and safety when developing corridor plans. Performance measures may include bicycle counts and bicycle level of traffic stress.
- ❑ Include bicycle accommodations or facilities to a project using the SHOPP tool. Bicycle facilities can be added as part of an existing project or during resurfacing.
- ❑ Use the Caltrans Bicycle Facility Classifications to identify the most appropriate bicycle facility for each project.

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- Caltrans Complete Streets SHOPP Tool
- NACTO Urban Street Design Guide
  https://nacto.org/publication/urban-street-design-guide/
- FHWA Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/
- FHWA PedSafe/Bike Safe Countermeasures
  http://www.pedbikesafe.org/
- ITE Recreational Design Guidelines to Accommodate Pedestrians and Bicyclists at Interchanges
  https://trid.trb.org/view/1312802
- Caltrans Toward an Active California Appendix: Performance Measures
- FHWA Guidebook for Developing Pedestrian and Bicycle Performance Measures
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/

2.2 PROVIDE BICYCLE FACILITIES

Bicycle facilities, including shared-lane markings, bike lanes, bike boxes, and separated bikeways, can provide designated places for people to bicycle comfortably. Bicycle facilities should be designed according to the road classification, traffic volumes, speed, and place type. On rural roads, wide, paved shoulders may be the most appropriate solution, while in urban areas, separated bike lanes are often needed for roadways with high traffic volumes. Bicycle facilities may also be constructed adjacent to a road in the right of way.

Source: California Department of Transportation

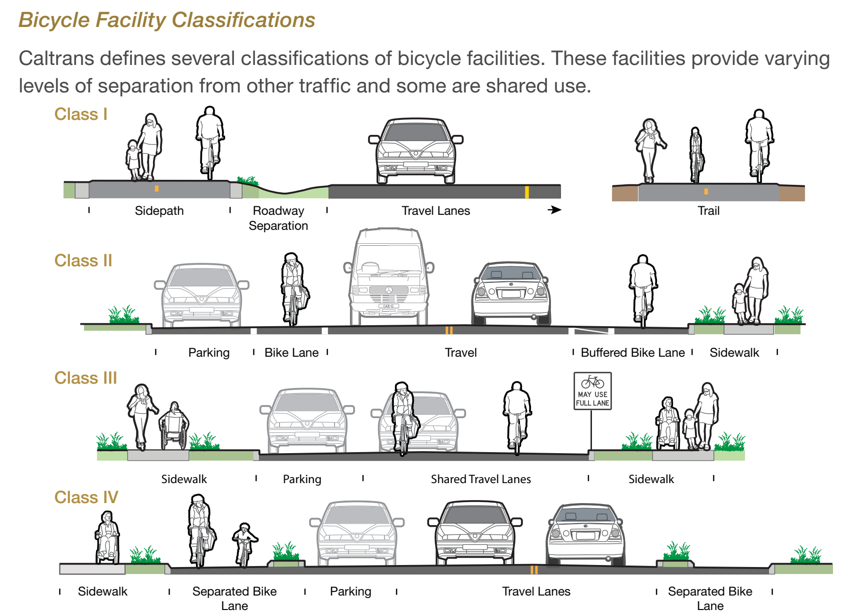
Generally speaking, bicyclist comfort increases with increased separation from vehicle travel. Higher vehicle volumes and higher speeds often require more separation to appeal to the majority of bicyclists. Separation from traffic can be achieved by painted lines, buffers, or physical separations such as curbs, bollards, flexposts, as well as completely separated bike paths located parallel to the street.[23] The level of separation required for user comfort may depend on traffic speeds, traffic volumes, and street widths.

While there are many design options for bicycle facilities, Caltrans uses four classifications (Class I-IV) to describe bicycle travel facilities, primarily defined by the level of separation from vehicle traffic, as shown in Figure 18.

Bicycle lanes can be added during resurfacing or as part of another project. In some cases, parking or travel lanes may need to be removed to accommodate bicycle facilities when right-of-way is constrained. In other cases, it may be possible to reduce the width of travel lanes to allow the inclusion of new bicycle facilities while maintaining the current number of travel lanes. Removing travel lanes will not necessarily increase traffic congestion. Each project must be analyzed to determine impacts across modes. A bicycle level of traffic stress analysis, described later in this section, can help planners determine the type of bicycle facility appropriate for a project.

Studies show that increasing bicycle infrastructure is correlated with increased rates of bicycling.[24, 25] Provision of bicycle infrastructure alone, however, does not necessarily cause more cycling. Infrastructure should connect key origins and destinations, and supporting programs, education, and encouragement strategies should be employed to attract new riders.[26] Linking bicycle facilities to create a full network is important to facilitate bicycling as transportation, rather than just a recreational activity. Planners should accommodate bicycle travel through potential barriers, including highways.

Figure 18: Caltrans Bicycle Facility Classifications



Source: Caltrans Toward an Active California

Figure 19: US-101 Class 1 Bike Path in Ventura County

Source: California Department of Transportation

Figure 20: Multi-use Path Under Route 17 in Campbell

Source: City of Campbell

STRATEGY AT A GLANCE

2.3 CONDUCT BICYCLE AND PEDESTRIAN COUNTS

STRATEGY SUMMARY

- ❑ Conduct manual or automated counts of pedestrians and bicyclists on key intersections for at least one week to account for variations in hour, day, and weather, which affect nonmotorized transportation more than vehicular transportation.
- ❑ Conduct counts, including movement details and traveler behaviors, in early phases of the planning process, to determine appropriate designs or countermeasures, or after construction, to measure impacts.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- Caltrans. Toward an Active California.
- Transportation Research Board. NCHRP Report 797: Guidebook on Pedestrian and Bicycle Volume Data Collection http://www.trb.org/Publications/Blurbs/171973.aspx

2.3 CONDUCT BICYCLE AND PEDESTRIAN COUNTS

Planners can collect data to measure bicycle and pedestrian activity and determine appropriate facility designs. Gathering data on bicycle and pedestrian movements can identify common routes and crossing movements, which can inform the need for safety improvements and help evaluate the impacts of infrastructure projects. Short-term counts should be collected over a period of at least one week to account for variations in hour, day of the week, and weather. While manual counts may be conducted, automated counts are the most efficient method of collecting data. Bicycle and pedestrian counts ideally should be conducted on a regular basis. Counts can be collected in early phases of the planning process, prior to developing design concepts in order to help determine appropriate designs or countermeasures, and should be collected again after a project has been completed, to measure impacts.

When counting pedestrians and bicyclists, individuals should be both counted and classified by movements (e.g., “through intersection, turn left”). Bicyclists should also be classified as traveling with traffic or contraflow to identify common routes and traffic patterns. Although there is not a state-standardized system for collecting counts, Caltrans recommends collecting the following data when conducting bicycle and pedestrian counts:

- Location – street or intersection name, side of street, or point location
- Facility being observed – sidewalk, bike lane, general traffic lane, whole street
- Movement being observed – bicycling, walking, direction of travel, turning movements
- Detector – manual or automatic, technology, serial number
- Period of observation – start and end time
- Counts – volumes
- Observations – for more detailed information about individual manual observations such as helmet use, age, gender, and wrong way travel.[27]

Toward an Active California describes counting methodologies, including use of automated counters, which are available for use by Caltrans District offices. Additionally, the *NCHRP Guidebook on Pedestrian and Bicycle Volume Data Collection* includes recommended data collection methodologies, including technology and data analysis, such as extrapolation factors.[28]

STRATEGY AT A GLANCE

2.4 CONDUCT BICYCLE LEVEL OF STRESS ANALYSIS

STRATEGY SUMMARY

- ❑ Perform a bicycle level of traffic stress analysis, which defines bicycle routes based on bicyclist comfort levels.
- ❑ Use the results of the analysis to determine bicyclist needs along a corridor or in a bicycle network.
- ❑ Use the results of the analysis to identify appropriate bicycle facilities for segments in the corridor or network.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- Mineta Institute. Low-Stress Bicycling and Network Connectivity https://transweb.sjsu.edu/research/low-stress-bicycling-and-network-connectivity
- Caltrans. Toward an Active California
- Caltrans District 4 Bicycle Plan
- Northeastern University. Peter Furth LTS Criteria Tables http://www.northeastern.edu/peter.furth/research/level-of-traffic-stress/

2.4 CONDUCT BICYCLE LEVEL OF STRESS ANALYSIS

A bicycle level of traffic stress (LTS) analysis classifies streets based on the perspective of four types of bicyclists. The bicyclist typologies are commonly referenced in relation to the degree of protection from vehicles on roadways. Streets are measured primarily by the number of vehicle travel lanes, speed of traffic, and bicycle facility characteristics (if present). Additional factors may be included in the analysis, such as the presence of parking, frequency of bicycle facility blockages, type of intersection control, and pavement quality.

The level of traffic stress analysis can be applied to individual streets or to a larger network. A network analysis is helpful in understanding barriers along routes and between destinations. Planners may apply the LTS analysis to an individual roadway, a corridor, or an area or city-wide network. Note that a level of stress approach can also be applied to pedestrian facilities, but the science of pedestrian stress isn't as advanced as bicycle LTS so a specific metric cannot be recommended at this time.

LTS scores range from 1-4, with LTS 1 being the most comfortable for all riders, including children, and LTS 4 appealing to only the most confident bicyclists (commonly described as "strong and fearless," who are comfortable and sometimes prefer to travel in mixed traffic). Note that Caltrans classifies bicycle facilities as Class I through Class IV, which do NOT correspond to LTS 1-4 scores.

Methods for conducting a LTS analysis can be found in the paper *Low-Stress Bicycling and Network Connectivity* published by the Mineta Transportation Institute.[29] Methods in this paper form the basis of the analysis for LTS recommended in *Toward an Active California*. Table 2 describes LTS scores for streets with a variety of speeds and lanes.

For a more detailed analysis, planners should consult the *Low-Stress Bicycling and Network Connectivity* paper, or the Caltrans District 4 Bicycle Plan, as examples. Further information can also be found on Northeastern University's website for Professor Peter Furth, one of the developers of the LTS analysis method.[30] As an example, Table 3 lists criteria for bike lanes installed next to a parking lane for each LTS score.

Table 2: LTS Typical Examples

LTS Score	User Group	Typical Facility Examples
1	The level most children can tolerate	Off-street paths
2	The level that will be tolerated by the mainstream adult population	Low speed, shared streets, bike lanes on low volume streets
3	The level tolerated by American cyclists who are "enthused and confident" but still prefer having their own dedicated space for riding	Bike lanes on higher volume streets
4	A level tolerated only by those characterized as "strong and fearless"	No facility provided

Source: Caltrans District 4 Bike Plan Appendix

Table 3: LTS Criteria for Bike Lanes Alongside a Parking Lane

	LTS ≥ 1	LTS ≥ 2	LTS ≥ 3	LTS ≥ 4
Street width (through lanes per direction)	1	2, if separated by raised median	≥2, or 2 without a raised median	no effect
Bike lane width	≥ 6 ft	≤ 5.5	no effect	no effect
Speed limit or prevailing speed	≤ 30 mph	no effect	35 mph	≥ 40 mph
Bike lane blockage	rare	no effect	frequent	no effect

Note: "No effect" indicates that the factor does not trigger an increase to this level of stress

Source: Caltrans District 4 Bike Plan Appendix

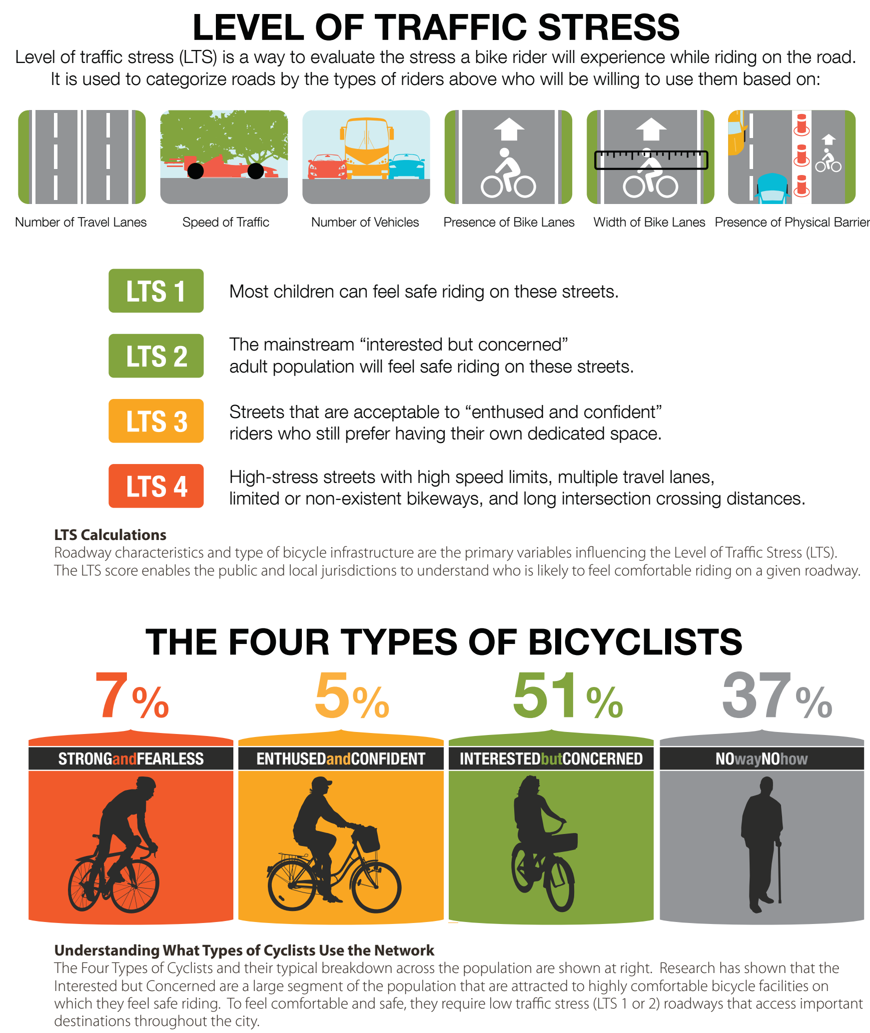
The LTS Analysis for the BMP was conducted in GIS in a manner consistent with the methodology developed by Merkuria, Furth, and Nixon. .

As shown in **Figure 3-3**, most streets in Stockton are low-stress bikeways; however, nearly all of the City's crosstown arterials and collectors are high stress. Low-stress bikeways (LTS 1 and 2) make up about two-thirds of Stockton's streets and permeate the City's residential neighborhoods. Yet, it is difficult to find low-stress routes that allow for traveling between neighborhoods, accessing major destinations, and crossing major geographic barriers. Most destinations for employment (e.g., Downtown), shopping (e.g., Lincoln Center), and education (e.g., Delta College) can only be accessed via high-stress facilities, constraining mobility options for all but the most confident bicyclists in Stockton.

The most common factors contributing to high LTS scores across Stockton include high posted speed limits (30-45 MPH), wide streets with multiple lanes, and a lack of bicycle lanes and paths. Additionally, many low-stress residential side street segments received high LTS scores at unsignalized crossings of arterials; these "weak links" can turn what would otherwise be a low-stress facility into a high-stress route.

CITY OF STOCKTON
Bicycle Master Plan

Figure 21: Level of Traffic Stress / Four Bicyclist Types



Source: Stockton Bicycle Master Plan.

STRATEGY AT A GLANCE

2.5 IMPROVE TRANSIT AND CONNECTIONS TO TRANSIT

STRATEGY SUMMARY

- ❑ Work with local governments to apply for Caltrans funding for transit.
- ❑ Identify opportunities to improve transit on state owned roads (such as bus-on-shoulder operations) or improved access to transit (such as high visibility crosswalks or bicycle parking).
- ❑ Include performance measures for transit in corridor plans. Performance measures could include average transit travel times, modal connections around hubs, mode share, and bike racks at major transit stops.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- CA Manual on Uniform Traffic Control Devices https://dot.ca.gov/programs/traffic-operations/camutcd
- NACTO. Urban Street Design Guide https://nacto.org/publication/urban-street-design-guide/
- FHWA. Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/
- APTA. Design of On-Street Transit Stops and Access from Surrounding Areas https://http://www.apta.com/wp-content/uploads/Standards_Documents/APTA-SUDS-UD-RP-005-12.pdf
- San Diego Regional Mobility Hub Implementation Strategy https://www.sdforward.com/fwddoc/mobipdfs/mobilityhubcatalog-features.pdf

2.5 IMPROVE TRANSIT AND CONNECTIONS TO TRANSIT

While transit agencies are largely responsible for the service and performance of transit, there are opportunities for state and local planners to improve access to transit, and in some cases, the systems themselves.

Transit Service Improvements

State and local agencies can make accommodations for transit by adjusting signal timing to prioritize transit. Where allowed, bus operation in highway shoulders can improve transit travel time and reliability. State and local agencies can also support transit through funding mechanisms. Caltrans supports integrating bus rapid transit on the highway system, per its policy directive on BRT Implementation Support. [31,32]

Caltrans has partnered with local and regional agencies, including Santa Cruz County and the San Diego Association of Governments, to implement bus-on-shoulder demonstrations, where bus service is routed along state-owned roads and highways. Service may be routed on shoulders during congested periods to reduce bus delay.[33]

Some municipalities prioritize transit at traffic signals, especially as signal timing technology has advanced. The *CA Manual on Uniform Traffic Control Device*s includes information on establishing prioritized signal timing for buses. Prioritization for buses approaching traffic signals can be applied to signals on state and local roads to improve the efficiency of transit service. [34]

Although transit systems are more extensive in urban areas, rural communities benefit from transit as well. Transit-dependent populations living in rural areas sometimes rely on transit for employment access and daily needs. Prioritizing routes that access major employment centers or medical services can reduce some SOV travel and improve access for those who are transit dependent. Additionally, seasonal service or paratransit can support mobility in areas with limited funding or density too low to support a more robust system.

Caltrans administers funds for transit operations and capital expenditures through the State Transit Assistance Program and other competitive programs, including:

- State of Good Repair Program (maintenance and capital projects)[35]
- Solutions for Congested Corridors Program (eligible projects, including transit, must be part of a corridor plan to reduce congestion)[36]
- Transit and Intercity Rail Capital Program (transit and rail capital projects designed to reduce congestion)[37]

Local governments and transit agencies can nominate transit projects for funding from these programs. Local governments may also raise or allocate funds to support transit service. State, local agencies, and transit agencies should also work together to ensure transit systems are coordinated to facilitate inter-city and multimodal travel.

Figure 22: Bus-on-shoulder

Source: TransitWiki

Figure 23: Rural and On-Demand Transit Service

Source: California Department of Transportation

Figure 24: Bike Rack on Bus

Source: California Department of Transportation

Access to Transit

Bus and rail lines are often just one link in a transit journey. By creating and maintaining accessible and comfortable routes to transit stops and multimodal accommodations at transit stations and hubs, public agencies can expand the reach of the transit system, addressing first/last mile considerations and making it possible for more people to use the system. For major transfer points or highly populated areas, some public agencies are encouraging mobility hubs, described as centers with multiple transportation options and connections.

Specific strategies for mobility hubs can include:

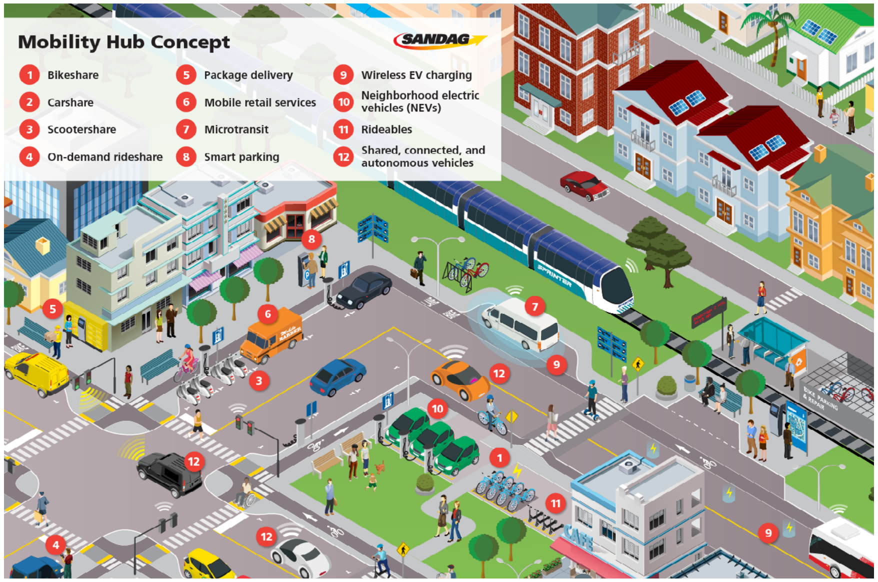
- Improving pedestrian crossings and walkways around mobility hubs
- Installing digital wayfinding signage with real time travel information
- Establishing priority signal timing for buses in proximity to mobility hubs
- Designating areas for passenger loading zones, vehicle parking, and secure bicycle parking
- Use of "flexible curb space" to allow the mobility network to better balance street demands as they change throughout the day

Not every transit stop needs to be a major transfer zone. In some areas, improving the quality of walking and bicycle access to bus stops can go a long way to improving the safety and quality of the bus system. Features may include: proximity to marked crosswalks with curb ramps and detectable warning pads at transit stops, space for wheelchair maneuverability, real time information, ADA-accessible real time information, seating, street trees, and lighting.

First/last mile considerations may vary by location or place type. In urban areas, walking, bicycling, or micromobility options (such as scooters) may be common first/last mile modes. In suburban and rural areas, walking and bicycling may still apply for travelers connecting to bus service, but planners may also consider park -and-ride facilities and drop-off areas for ridesharing.

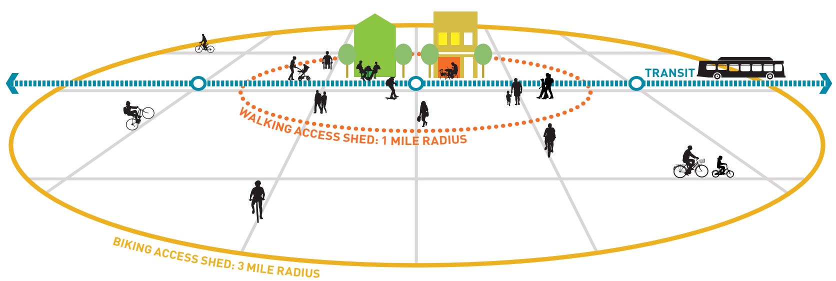
Efforts to improve transit access should consider the concept of the "access shed" as a way to identify and prioritize investments. For example, the vast majority of walk trips are less than one mile, and most bike trips are less than three miles. Other forms of mobility (e.g., scooters) will have different travel characteristics. Figure 26 illustrates the concept of an access shed around a transit stop.

Figure 25: SANDAG Mobility Hub Example



Source: SANDAG, San Diego Forward The Regional Plan, 2019-2050

Figure 26: Access Shed



Source: Atlanta Regional Commission, "Walk. Bike. Thrive!"

STRATEGY AT A GLANCE

2.6 MANAGE CURB SPACE TO ACCOMMODATE NEW MODES & ACTIVITY

STRATEGY SUMMARY

- ❑ Conduct curb audits in areas with high rates of double parking or drop-off/pick-ups.
- ❑ Designate loading zones for delivery and taxis/TNCs in congested areas.
- ❑ Work with local governments to designate preferred parking area for dockless bicycles or PMDs.
- ❑ Work with local governments to regulate shared mobility companies. Regulations may include but are not limited to requiring education for riders or collecting operating fees.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- Institute of Traffic Engineers. Curbside Management Practitioners Guide https://www.ite.org/pub/?id=C75A6B8B-E210-5EB3-F4A6-A2FDDA8AE4AA
- International Transport Forum. The Shared-Use City: Managing the Curb https://www.itf-oecd.org/shared-use-city-managing-curb-0
- NACTO Managing Mobility Data https://nacto.org/managingmobilitydata/

2.6 MANAGE CURB SPACE TO ACCOMMODATE NEW MODES & ACTIVITY

As transportation network companies (TNCs) increase in popularity, the frequency of drop-offs and pick-ups along streets will also increase. TNCs may block travel lanes, including bike lanes, slowing traffic and creating potentially dangerous environments for bicyclists and pedestrians. Without intervention, curb space is often utilized for low-cost or free parking, which yields fewer benefit to cities than if that space was reallocated to dedicated transit lanes, bike lanes, or temporally managed drop-off and pick-up lanes for passengers and freight movement. Planners can conduct curb audits to observe drop-off and pick-up activity, double-parked vehicles, deliveries, or similar activity which may block traffic or create barriers for bicyclists and pedestrians. Curb audits are most likely useful in commercial areas with limited areas for stopping outside of the travel lanes. In areas with high rates of drop-offs/pick-ups, double parking, or other conflicts, planners can designate space for stopping activity in order to avoid vehicles stopping or idling in travel lanes.

Dockless shared bicycles and electric scooters, along with other personal mobility devices (PMDs), are also becoming more common. These vehicles are more prevalent in urban areas, but commercial centers in small towns may see increased use as well. Parked bicycles and scooters can compete with pedestrians for space on sidewalks and can sometimes block pedestrian pathways. Cities can install bicycle racks or dedicated parking areas on sidewalks or designate parking spaces on the street for personal or shared bicycles and PMDs. In the case of new bicycle and scooter share services, municipalities can craft regulations and require permits for operations in order to help manage use and provide infrastructure or supportive services. Examples of regulations for shared mobility companies include collecting operating fees, requiring education of legal and safe operations to riders, and requiring rental options for persons without credit cards (to alleviate equity concerns). Additionally, some municipalities are testing designated parking spaces and even specially designed racks for electric bicycles, scooters, and skateboards to help keep these parked vehicles out of the pedestrian right of way.

To better manage curb space, planners can measure drop-off/pick-up and double parking activity in commercial areas where potential conflicts are common. The District of Columbia Department of Transportation (DDOT) and the Golden Triangle Business Improvement District used a time-lapse camera to conduct a curb audit in the Golden Triangle Area, counting the number of drop-offs/pick-ups and deliveries along the street. DDOT established shared mobility zones, which converted some on-street parking spaces to areas designated for passengers drop-offs/pick-ups and deliveries at specific periods of the day.[38]

TNC or rideshare data can be difficult to obtain, as the data is owned by private companies. As TNC use becomes a more commonly used form of transportation, government agencies and private companies will need to work together to share data to accommodate this emerging transportation mode. The National Association of City Transportation Officials (NACTO) *Managing Mobility Data* is a guide to facilitate data sharing from TNCs in order to protect private information while providing vital information for transportation agencies.

BICYCLE AND PEDESTRIAN PERFORMANCE MEASURES

PROJECT SCALE	PERFORMANCE MEASURES	DATA SOURCES	RESOURCES
SINGLE PROJECT	• Bicycle / pedestrian counts • Percent of bicyclist and pedestrian fatalities and serious injuries	• Caltrans GIS Highway Data, District-collected counts, Local or regional counts, third party data provider, such as Streetlight data • Collision data from the Statewide Integrated Traffic Records System (SWITRS), street-level count data, American Community Survey, National and California Household Travel Surveys, hospital records	• NCHRP Report 797: Guidebook on Pedestrian and Bicycle Volume Data Collection • Caltrans Toward an Active California
LOCAL NETWORK	• Bicycle Level of Stress analysis • Percent of bicyclist and pedestrian fatalities and serious injuries • Mode share	• Caltrans GIS Highway Data, District-collected bicycle facility data • Collision data from SWITRS, street-level count data, American Community Survey, National and California Household Travel Surveys, hospital records • California Household Travel Survey, National Household Travel Survey, American Community Survey, Local or regional surveys, ridership volumes from transit agencies	• MIneta Transportation Institute. Low-Stress Bicycling and Network Connectivity • Caltrans Toward an Active California • NCHRP Report 797: Guidebook on Pedestrian and Bicycle Volume Data Collection

TRANSIT PERFORMANCE MEASURES			
PROJECT SCALE	**PERFORMANCE MEASURES**	**DATA SOURCES**	**RESOURCES**
SINGLE PROJECT	• Percent of bus stops in close proximity to crossings • Percent of buses with bicycle racks • Average transit route speed or travel time • Variability or range in transit travel times • On-time performance	• Caltrans GIS Highway Data, transit agency data, site visit • Transit agency data • Transit agency data, GTFS data, Field surveys • Field surveys Automatic vehicle location (AVL) system	• FTA Manual on Pedestrian and Bicycle Connections to Transit • TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System • NACTO. Making Transit Count: Performance Measures That Move Transit Projects Forward • Florida DOT. Best Practices in Evaluating Transit Performance
LOCAL NETWORK	• Number of modal connections at transit hubs • Service coverage (Percent of area served by transit) • Mode share	• Caltrans GIS Highway Data, District-collected bicycle facility data • Transit route GIS layer • California Household Travel Survey, National Household Travel Survey, American Community Survey, Local or regional surveys	• NCHRP Research Results Needs 361: State DOT Public Transportation Performance Measures: State of the Practice and Future Needs • TCRP Report 88: A Guidebook for Developing a Transit Performance-Measurement System

CURB SPACE PERFORMANCE MEASURES		
PROJECT SCALE	**PERFORMANCE MEASURES**	**DATA SOURCES AND RESOURCES**
SINGLE PROJECT	Number of double parked vehicles or number of drop-offs/pickups	• Site visit / video counts • International Transport Forum. The Shared-Use City: Managing the Curb

RESOURCES: FACILITY DESIGN

- California Highway Design Manual
  https://dot.ca.gov/programs/design/manual-highway-design-manual-hdm
- CA Manual on Uniform Traffic Control Devices
  https://dot.ca.gov/programs/traffic-operations/camutcd
- NACTO Urban Street Design Guide
  https://nacto.org/publication/urban-street-design-guide/
- NACTO Transit Street Design Guide
  https://nacto.org/publication/transit-street-design-guide/
- AASHTO Guide for the Development of Bicycle Facilities
  https://store.transportation.org/Item/CollectionDetail?ID=116
- FHWA Achieving Multimodal Networks:
  Applying Design Flexibility and Reducing Conflicts
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/fhwahep16055.pdf
- FHWA Small Town and Multimodal Networks
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf
- FHWA PedSafe/Bike Safe Countermeasures
  http://www.pedbikesafe.org/bikesafe/guide_analysis.cfm
- Institute of Traffic Engineers. Curbside Management Practitioners Guide.
  https://www.ite.org/pub/?id=C75A6B8B-E210-5EB3-F4A6-A2FDDA8AE4AA
- ITE Recreational Design Guidelines to Accommodate Pedestrians and Bicyclists at Interchanges
  https://trid.trb.org/view/1312802
- APTA Design of On-street Transit Stops and Access from Surrounding Areas
  https://www.apta.com/wp-content/uploads/Standards_Documents/APTA-SUDS-UD-RP-005-12.pdf
- San Diego Regional Mobility Hub Implementation Strategy
  https://www.sdforward.com/fwddoc/mobipdfs/mobilityhubcatalog-features.pdf

RESOURCES: BICYCLE AND PEDESTRIAN PERFORMANCE MEASURES

- Caltrans Toward an Active California Appendix: Performance Measures
- FHWA Guidebook for Developing Pedestrian and Bicycle Performance Measures
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/pm_guidebook.pdf
- Bike Berkeley Appendix: Level of Traffic Stress
  http://www.bikeberkeley.com/wp-content/uploads/2015/02/Appendix-C_-Level-of-Traffic-Stress_reduced-1.pdf
- NCHRP Methods and Technologies for Pedestrian and Bicycle Volume Data Collection: Phase 2
  http://www.trb.org/main/blurbs/175860.aspx

Example: Bike Lane Striping and Lane Reduction on SR 273

> CASE STUDY AT A GLANCE

STRATEGIES

Provide Bicycle Facilities, Improve Safety for Vulnerable Road Users

KEY TAKEAWAYS

- Adding bicycle facilities and reducing lanes on state highways serving as Main Streets can reduce conflicts for pedestrian and bicycle traffic in downtown districts.
- Bicycle striping and lane width reductions can be implemented as part of a resurfacing or other highway maintenance project.

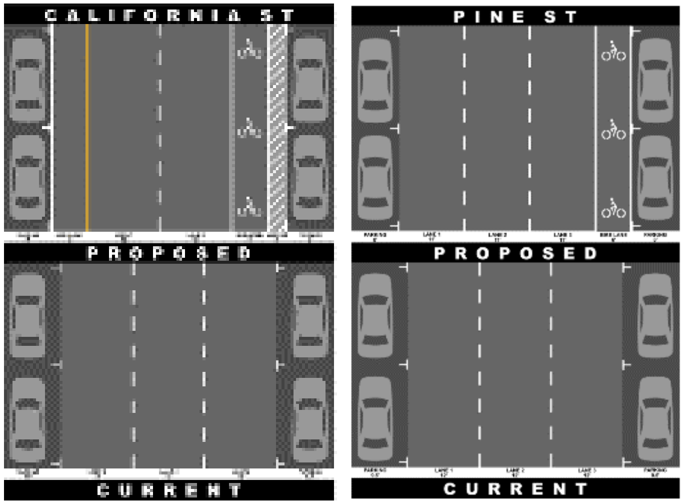
RESOURCES

- Caltrans. SR 273 Transportation Concept Report
- Caltrans. Encroachment Permits Manual https://dot.ca.gov/programs/traffic-operations/ep/ep-manual

State Route 273 travels through downtown Redding in Shasta County. SR 273 is a former segment of historic route US 99, a main link between Canada and Mexico. Today, SR 273 is used by local traffic within Shasta County. In downtown Redding, the route splits into two one-way streets, Pine Street and California Street. The City of Redding and local community groups, including Shasta Living Streets, sought to revitalize Redding's downtown district by improving the safety and comfort of walking and bicycling in the area.

In 2013, Caltrans District 2 studied the feasibility and impacts of adding bike lanes as part of a highway maintenance project and proposed Class II bike lanes on both Pine Street and California Street. Pine Street and California both had three 12-foot travel lanes and parking on both sides of the street. The final design for Pine Street added a Class II 6-foot bike lane, reduced the three travel lanes to 11 feet, and reduced the parking lanes to 8 feet. California Street was redesigned to include a Class II 6-foot bike lane with 3-foot buffer, two 12-foot travel lanes, 8-foot parking lanes and a 6-foot shoulder on the opposite side of the street as the bike lane. The lane reduction on California Street reduced conflicts for pedestrians and the shoulder and buffer allowed more space for people to enter and exit parked vehicles without concerns of interactions with traffic. Class II bike lanes were consistent with the *2013 Transportation Concept Report for SR 273.*[39] Caltrans also issued a permit for a parklet demonstration on California Street, the first parklet pilot on a state-owned road in California.

Figure 27: Pine and California Street Configuration Before and After Resurfacing/Restriping Project



Traffic Volume Data, SB on California

- AADT=7,150 vehicles
- Peak Hour = 790 v/h

Traffic Volume Data, NB on Pine

- AADT=10,700 vehicles
- Peak Hour = 1,200 v/h

Source: Caltrans SR 273 Transportation Concept Report

Example: Montgomery County Bikeway Network Level of Traffic Stress

> CASE STUDY AT A GLANCE

STRATEGIES

Conduct a Bicycle Level of Traffic Stress Analysis

KEY TAKEAWAYS

- A bicycle level of traffic stress map, displayed through an interactive website, provides bicyclists with valuable information for selecting appropriate routes based on each users own stress tolerance level.
- LTS-related data can be gathered from open source resources such as Google Streetview and/or Open Street Maps analyses.

RESOURCES

- Montgomery County Bicycle Master Plan Appendix D: LTS Methodology https://montgomeryplanning.org/wp-content/uploads/2017/11/Appendix-D.pdf
- Montgomery County Bicycle Stress Map www.mcatlas.org/bikestress/

Montgomery County, MD calculated the Level of Traffic Stress (LTS) for every roadway in the County (except freeways) as well as off-street paths. LTS is intended to quantify the amount of stress that bicyclists feel when they ride close to vehicle traffic at different speeds, volumes, and other roadway characteristics. The results are displayed on a website (www.mcatlas.org/bikestress/) that color codes roadways according to the LTS, allows users to set their own stress tolerance level, and shows routes or networks that are appropriate for each type of cyclists.

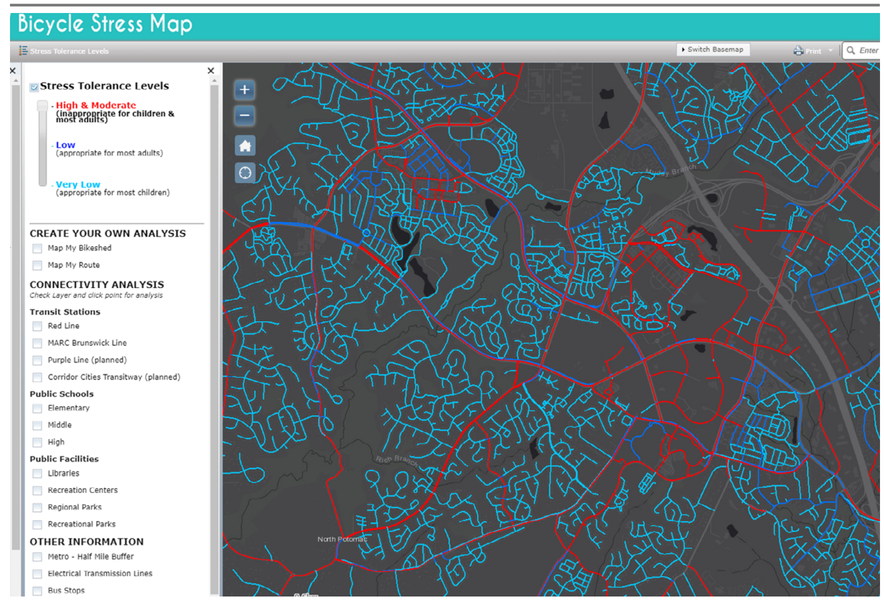
The county developed its own modified methodology for calculating LTS.[40] The methodology considers factors such as:

- Type of bicycle facility (mixed traffic, bike lane, separated bike lane, shared use path, etc.)
- Bike lane width
- Posted speed limit
- Number of through lanes
- Presence of parking
- Parking turnover rates and frequency of parking obstructions

The website also includes short videos that provide examples of bicycling on roadways in the county with different stress levels.[41]

Collecting data for an LTS methodology can be resource-intensive to achieve high levels of accuracy. Recent research suggests that high levels of accuracy can be achieved from a combination of data collection from Open Street Maps, combined with sampling field checks for quality assurance.[42]

Figure 28: Montgomery County Level of Traffic Stress Analysis



Source: Montgomery County

Example: Caltrans District 4 Level of Traffic Stress Analysis

> CASE STUDY AT A GLANCE

STRATEGIES

Conduct a Bicycle Level of Traffic Stress Analysis

KEY TAKEAWAYS

- Level of Traffic Stress (LTS) analyses using state GIS data can help identify bicycle needs by measuring the comfort of a bicycle facility based on facility type, traffic speeds, and traffic volumes.
- Open source or other resources can fill in data gaps to conduct robust analyses.
- Planners can use existing LTS analysis methodologies or tailor methodologies to address specific locations, such as highway crossings.

RESOURCES

- Mineta Transportation Institute report: Low Stress Bicycling and Network Connectivity https://transweb.sjsu.edu/sites/default/files/1005-low-stress-bicycling-network-connectivity.pdf
- Caltrans District 4 Bike Plan
- Open Street Map http://www.openstreetmap.org
- Northeastern University. Peter Furth LTS Criteria Tables http://www.northeastern.edu/peter.furth/research/level-of-traffic-stress/

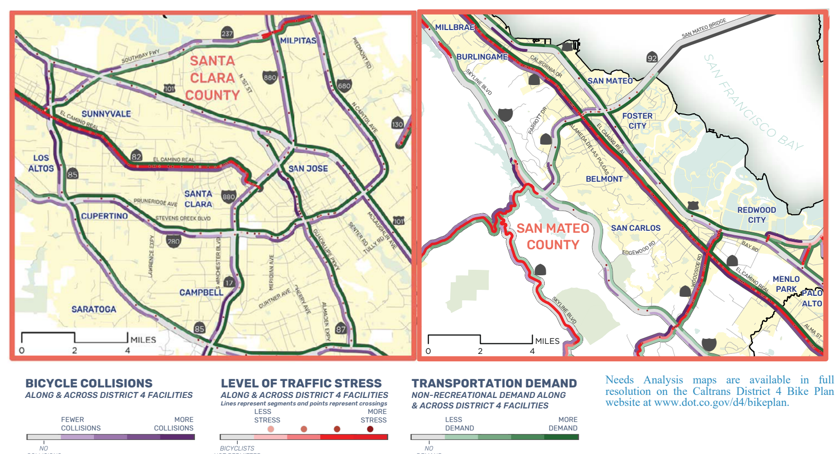
Caltrans District 4 conducted a Level of Traffic Stress (LTS) analysis to identify roads and intersections with high levels of traffic stress, indicating that many bicyclists and would-be-bicyclists feel unsafe or uncomfortable using those facilities. District 4 staff assigned LTS scores to all state highways and crossings in its jurisdiction, based on facility characteristics defined in the Mineta Transportation Institute report: *Low Stress Bicycling and Network Connectivity*.[43]

To perform the analysis, District 4 used the following data:

- Caltrans GIS data on vehicle speeds, volumes, and space for bicyclists
- Caltrans GIS data and Open Street Map data for intersections, ramps, and local approaches to crossings[44]

District 4 used a modified scoring system designed to address the unique needs of intersections on state highways, taking into account both conditions at the crossing as well as conditions along the approach to the intersection. To conduct the analysis, District 4 supplemented state GIS data with Open Street Map data to analyze highway ramp characteristics, The state GIS database does not currently record the facility data for highway ramps that are required for LTS analyses. Open Street Map is an openly available crowdsourced map of the world with geospatial data on transportation networks and other map features, which offers useful data where gaps may arise. The results of the analysis were mapped and overlaid with bicycle collision data and transportation demand data, which helped form the Needs Analysis for the District 4 Bicycle Plan.

Figure 29: Caltrans District 4 Level of Traffic Stress Analysis



Source: Caltrans District 4 Bike Plan

3. Speed Suitability Strategies

1. IMPROVE SAFETY FOR VULNERABLE ROAD USERS

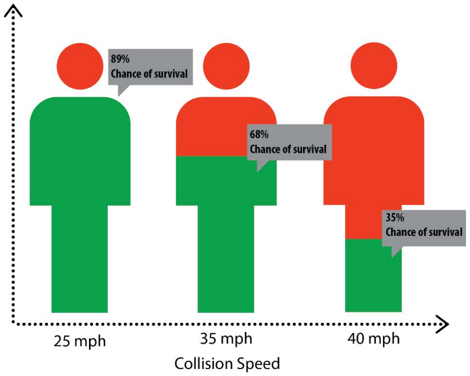
About Speed Suitability

The severity of collisions and risk of injury or fatality increases with vehicle speeds. As travel speeds increase, a driver's peripheral vision is reduced, limiting the ability to see pedestrians, bicyclists, or other roadway users. If a crash occurs, higher vehicle speeds dramatically increase the risk of severe injuries and fatalities to pedestrians and bicyclists. Figure 30 depicts this relationship, demonstrating that the faster a vehicle is traveling, the less likely it is that the person will survive.

This section discusses strategies to design, operate, and maintain the transportation system to achieve roadway speeds that reduce serious injuries and fatalities, including for the most vulnerable users. Like other sections in this document, some of the strategies go beyond Caltrans' current policies and procedures to reflect emerging practices that are consistent with the Smart Mobility Framework.

Recent national dialogue has focused on this topic, including a report from the National Transportation Safety Board (NTSB) titled *Reducing Speeding-Related Crashes Involving Passenger Vehicles*. The NTSB emphasized that speeding – exceeding a speed limit or driving too fast for conditions – increases not just the severity of injuries sustained by road users in a crash, but also the likelihood of being involved in a crash. The report concluded that managing speed must be the focus for meaningful improvements in traffic safety, with methods such as alternative approaches to speed limit setting and effective enforcement, including automated speed enforcement.

Figure 30: – Relationship between Vehicle Speed, Crashes, and Fatalities



Source: Tefft, B.C. "Impact speed and a pedestrian's risk of severe injury or death," Accident Analysis & Prevention 50 (2013), 871-878, cited in CalSTA Report of Findings: AB 2363 - Zero Traffic Fatality Task Force (2020)

While not all states can implement automated speed enforcement (including California), the industry is recognizing the need for new approaches and responding with a variety of speed suitability resources and actions. As such, the field is still emerging and best practice consensus has not been reached. As noted in CalSTA Report of Findings: AB 2363 - Zero Traffic Fatality Task Force (2020), there is clear evidence, supported by statistical analyses, that traffic fatalities and serious injuries increase with individual vehicle speed.

The primary goal of speed suitability is to reduce collisions and their severity for all road users. Special attention should be given to vulnerable road users, and speeds should be suitable to the type of facility, mix of users, and land use context. A related goal is to create a transportation network suitable and comfortable for mixed traffic conditions (i.e., vehicles, bicycles, scooters, and pedestrians) when the land use context warrants. The California Governor's Office of Planning and Research (OPR) has previously noted that "Speed is likely to be the single most important determinant of the number of traffic fatalities." [45]

Research has also found that higher speeds generally correlate with higher levels of noise pollution, and that roads with lower speeds in urban areas have more vibrant pedestrian activity and higher perceptions of a friendly street environment.[46]

Taken together, existing research shows how implementing the concept of speed suitability has numerous benefits for people on or adjacent to the roadway, and the cities that design and maintain the roadways. Suitable speeds are a function of the following factors:

- Land use context, Mix of users
- Road design
- Traffic operations/Traffic calming
- Enforcement

Of these factors, smart mobility focuses on the role that agencies play in road design and traffic operations. The process of setting speed limits is also important, especially in California where this process is largely dictated by law. Thus, in California, modifying speed limits is usually not an option for public agencies for managing suitable speeds.

> **"CalSTA's vision is to transform the lives of all Californians through a safe, accessible, low-carbon, 21stcentury multi-modal transportation system. However, the 85th percentile methodology relies on driver behavior. Greater flexibility in establishing speed limits would offer agencies an expanded toolbox in order to better combat rising traffic fatalities and injuries especially for the most vulnerable roadway users.."**
> CalSTA Report of Findings: AB 2363 - Zero Traffic Fatality Task Force (2020)

Flexibility in Design Standards

Operating speeds on roadways are a function of the 'design speed' used to establish geometric design elements of individual roadway sections. According to the Caltrans Highway Design Manual (HDM), Chapter 100, these design elements include vertical and horizontal alignment, and sight distance. In general, speed limits in California (and the U.S.) are set after a roadway is constructed and are derived from observed speeds based on the expectation that drivers will choose a comfortable speed based on the design elements noted above and the surrounding land use context. The design speed is one of the first decisions in the design or redesign of a road.[47]

National guidance emphasizes flexibility in design standards. In *Achieving Multimodal Networks*, FHWA discusses how documents such as memoranda and engineering studies can build a case for applying flexibility. Some designs may require a design decision document (design exception), and documentation is a key part of this process. In *Main Street, California*, Caltrans' guide for design of main streets in small towns, Caltrans echoes that it has a responsibility to enforce consistent applications of highway design standards while allowing for local context through design decision document (design exception).

Caltrans has identified a need to provide more flexibility in highway design standards and procedures, especially in the context of urban environment and multimodal design. In 2014, Caltrans issued a "Design Flexibility in Multimodal Design" memorandum, which highlights its flexible approach towards designing multimodal transportation projects on the state highway system as reflected in the Caltrans HDM, Chapter 80:

"The Project Development process seeks to provide a degree of mobility to users of the transportation system that is in balance with other values."

"A 'one-size-fits-all' design philosophy is not Departmental policy."

"This guidance allows for flexibility in applying design standards and approving design exceptions that take the context of the project location into consideration; which enables the designer to tailor the design, as appropriate, for the specific circumstances while maintaining safety."

The memorandum also mentions other resources: Publications such as the National Association of City Transportation Officials (NACTO) "Urban Street Design Guide" and "Urban Bikeway Design Guide," and the Institute of Transportation Engineers (ITE) "Designing Urban Walkable Thoroughfares," are resources that Caltrans and local entities can reference when making planning and design decisions on the State highway system and local streets and roads.

In addition to the HDM, Caltrans endorsed the National Association of City Transportation Officials (NACTO) *Urban Street Design Guide* in 2014.[48] Caltrans explained that the "endorsement of the NACTO guidelines is part of an ongoing effort to integrate a multimodal and flexible approach to transportation planning and design." Design flexibility is particularly important for speed management to allow for context sensitivity. At the same time, an emphasis on design flexibility and multimodal design supports other elements of smart mobility, such as multimodal choices.

STRATEGY AT A GLANCE

3.1 IMPROVE SAFETY FOR VULNERABLE ROAD USERS

STRATEGY SUMMARY

- Improve safety for vulnerable road users, with vertical and horizontal measures, as well as road narrowing, to reduce speeds in commercial areas or other areas to encourage multimodal transportation options and protect vulnerable users

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- Caltrans Main Street, California: A Guide for Improving Community and Transportation Vitality
  https://dot.ca.gov/-/media/dot-media/programs/design/documents/main-street-3rd-edition-a11y.pdf
- FHWA Traffic Calming ePrimer
  https://safety.fhwa.dot.gov/speedmgt/traffic_calm.cfm
- FHWA Proven Safety Countermeasures
  https://safety.fhwa.dot.gov/provencountermeasures/

3.1 IMPROVE SAFETY FOR VULNERABLE ROAD USERS

Many factors contribute to traffic fatalities and injuries, including speeding, distracted driving, and impaired driving. However, the relationship between speeding and traffic fatalities and injuries is an increasing subject of attention. Of the 37,133 traffic fatalities in 2017, 9,717 (26%) were involved in crashes where at least one driver was speeding. Nationwide, speeding contributes to approximately one-third of all motor vehicle fatalities. The relationship between speed and injury severity is especially critical for vulnerable road users such as bicyclists and pedestrians. In the U.S., on average, a pedestrian is killed in a motor vehicle crash every 88 minutes.[49]

After roadways have been constructed, design modifications and traffic operation changes that aim to influence driver speed generally fall under the umbrella of traffic calming. The FHWA and ITE developed the following definition of traffic calming:

"The primary purpose of traffic calming is to support the livability and vitality of residential and commercial areas through improvements in non-motorist safety, mobility, and comfort. These objectives are typically achieved by reducing vehicle speeds or volumes on a single street or a street network. Traffic calming measures consist of horizontal, vertical, lane narrowing, roadside, and other features that use self-enforcing physical or psycho-perception means to produce desired effects."[50]

CalSTA's Zero Traffic Fatalities Task Force (ZTFTF) Final Report recommended that Caltrans develop guidance for implementing traffic calming features on the State highway system. Initiated very recently (July 2020), there is a new effort in Caltrans Division of Design - with the Division of Traffic Operations as Co-Lead -, to develop traffic calming and lane narrowing policies and design guidance, which is an Assembly Bill (AB) 2363 Zero Traffic Fatalities Task Force (ZTFTF) recommendation. The goal is to ensuring success with implementing a policy and procedure that is widely applicable and accepted by both Caltrans and local agency partners.

The intent of the ZTFTF traffic calming and lane narrowing recommendation is consistent with the FHWA's Traffic Calming ePrimer, "... to improve the quality of life in both residential and commercial areas and increase the safety and comfort of walking and bicycling."

A traffic calming policy is needed that addresses specific engineering countermeasures that influence a driver's speed. The policy should include such speed management components as geometric design elements (e.g., number of lanes, width of lanes, roadbed width), as well as physical roadway intersection designs (e.g., roundabouts, single point interchanges, diverging diamond interchanges).

Traffic Calming measures can include: vertical measures that use the forces of acceleration to discourage speeding, horizontal measures that require drivers to reduce speeds by impeding straight-through movements, and road narrowing that conveys a sense of enclosure to discourage speed. Even a small change in vehicle operating speed can have large safety impacts. According to one, "a reduction of 3 mph in average operating speed on a road with a baseline average operating speed of 30 mph is expected to produce a reduction of 27% in injury crashes and 49% in fatal crashes."[51]

The following sections describe five measures being evaluated for implementation on Caltrans facilities to reduce vehicular speeds: roundabouts, lane reductions/road diets, lane width reductions, raised crosswalks, and Curb Extensions or Bulbouts. The descriptions include appropriate facilities where each measure may be considered and research on speed reduction potential, where available.

A key challenge for some measures is determining when they may be appropriate on Caltrans facilities, since Caltrans facilities often serve multiple purposes. Conventional highways such as State Route (SR) 49 connect communities across multiple counties. In this role, SR 49 is serving longer-distance passenger and freight trips. As SR 49 enters individual communities it also serves as Main Street where businesses front the roadway and more bicycle and pedestrian activity occurs. See Figure 31.

Figure 31: SR 49 in San Andreas, CA

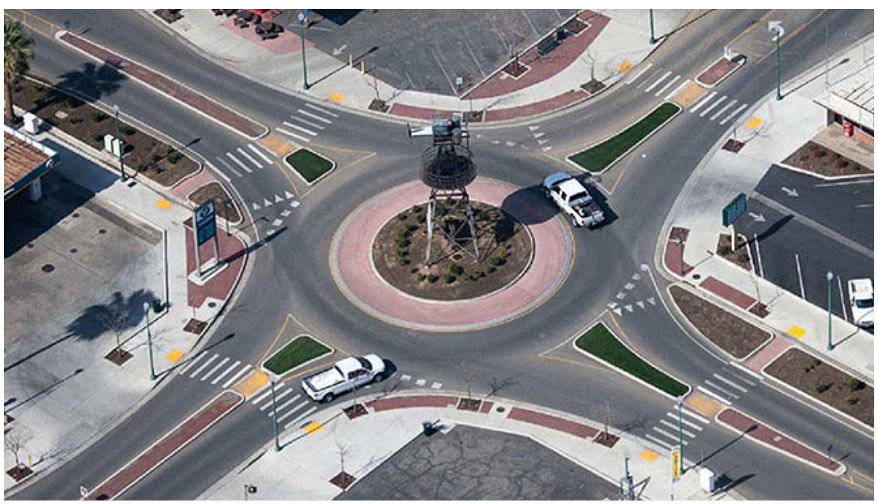
Source: Google Maps

The land use context is an important factor in determining whether a measure is a feasible as well as the amount and mix of traffic using the facility.

Roundabouts

A **roundabout** is an intersection design that generally follows a circular shape where traffic travels counter-clockwise around a central raised island with entering traffic yielding to the circulating traffic already in the roundabout. Approach geometry is used to create horizontal deflection that reduces approach speeds when combined with yield on entry. Speeds are also slow through the intersection as drivers navigate the circular roadway alignment. Roundabouts may be appropriate at the junction of arterial streets and of arterial streets with collector streets presuming compliance with Caltrans roundabout design policy. For Caltrans facilities, roundabouts would typically be considered at an intersection where there is a demonstrated need for intersection control. The design speed, land use, and access control context are important factors when considering roundabouts.

With sound design, roundabouts reduce speeds at all times of the day, which is an advantage over signal controlled intersections that focus on right-of-way assignment. Single-lane roundabouts are preferred over multilane roundabouts for pedestrians and bicyclists, as vehicles are more likely to yield to pedestrians on single-land roundabouts and they are easier for bicyclists to navigate.[52] Research has found reductions from 8-20 mph in the 85th percentile speed from installing roundabouts in different land use contexts.[53]For more information, see *NCHRP Report 672 Roundabouts: An Informational Guide.*



Source: FHWA, Traffic Calming ePrimer, 2017. Originally from Omni-Means, Ltd.

In some cases, reconfiguring a signalized or stop-controlled intersection into a roundabout intersection can provide an opportunity to convert excess traffic lanes into other uses such as bicycles lanes, wider sidewalks and/or landscaped areas.[54]
Landscaping within the central island of the roundabout, in the pedestrian crossing islands (splitter islands), or along the approaching roads provides environmental, aesthetic and traveler safety benefits. Appropriate landscaping and aesthetic treatments in the central island should convey to travelers that they are not to pass through the central island, maintain safety setbacks, encourage pedestrians to cross only at designated crossing locations and aesthetically integrate the intersection into the surrounding area. Roundabouts may have higher construction costs than other intersections but may also have lower life-cycle costs. Roundabouts often provide long-term fiscal benefits related to reduced congestion, reduced accident severity and the lack of traffic signals to install and maintain.[55]

Source: Main Street, California
This roundabout on State Route 89 in Truckee includes trees, landscaping and splitter islands with clearly designated pedestrian crossing locations.

Lane Reductions/Road Diets

Lane reductions, also known as road diets, change the cross-section of an existing roadway to reduce the number of motor vehicle travel lanes. The FHWA *Traffic Calming ePrimer* notes that "the most common application is the conversion of an undivided four-lane roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane." Reallocating the number of traffic lanes is a direct way of providing space within a limited right of way for other roadway and roadside features such as bike lanes, median plantings, pedestrian crossing islands, transit-only lanes and sidewalks. Lane reductions can be appropriate on arterial, collector, or local streets across all land use contexts.

Research has measured reductions between 1 and 5 mph in 85th percentile speeds, along with crash reductions between 17 percent and 62 percent due to lane reductions.[56] Lane reductions function to reduce the number of potential conflict points, and reduce the speed differential by eliminating passing lanes (particularly on four-to-three lane conversions). By slowing traffic and reducing crossing distances, they can also enable the use of lower cost crossing enhancements at uncontrolled crossings, such as those noted through the FHWA's Safe Transportation for Every Pedestrian (STEP) program.[57] For more information, see the FHWA *Road Diet Informational Guide*.[58]

Source: Main Street, California
A road diet project on State Route 35 (Sloat Boulevard) in San Francisco converted a traffic lane into a bike lane.

Lane reallocation decisions should be based on analyses of potential impacts to pedestrian, bicyclist, driver and transit rider mobility; vehicle congestion; traffic conflicts involving all travel modes; movement of freight; maintainability (particularly sweeping and snow removal); and adjacent land uses. Since reallocation of roadway space is a design and operations decision with numerous associated impacts on a project, it is vital that discussion of the various options occurs early in the planning process and includes meaningful stakeholder involvement.[59]

Source: Main Street, California
Five traffic lanes along State Route 299 in Willow Creek were reconfigured into two traffic lanes, a center turn lane and bike lanes in each direction. Livability was further improved by the addition of street trees, landscaping and marked crosswalks.

Lane Width Reduction

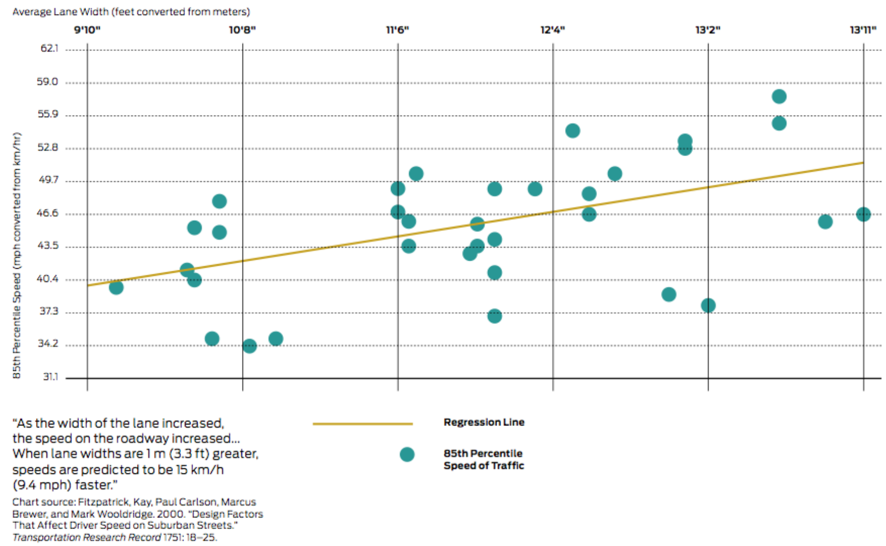
Lane width reductions, for lanes wider than 12 feet, may be a low-cost traffic calming treatment that may be implemented with a street resurfacing project, a roadway re-design (such as a road diet), or as a standalone project. According to CalSTA Report of Findings, a driver's operating speed can be influenced by many complex factors, but generally speaking, motorists will drive faster on wide, uncongested roads. They will drive slower on narrow roads with sight markers (such as trees) that provide subconscious feedback on their speeds.[60]

Narrower traffic lanes shorten crossing distances for pedestrians and bicyclists and can provide space for roadway elements like medians, bike lanes, sidewalks, on-street parking, transit stops and landscaping. In some cases, reduced lane widths in main street environments can influence drivers to maintain slower vehicle speeds, especially when undertaken in combination with other traffic calming strategies.[61]

In California, lane width for Caltrans and local roadways is commonly 12 feet although the Caltrans HDM allows a minimum lane width of 11 feet on conventional highways in urban, city, or town centers (i.e., rural main streets). The American Association of State Highway and Transportation Officials (AASHTO) publication, *A Policy on Geometric Design of Highways and Streets* – also known as the "Green Book" – allows for flexibility and engineering judgment in designing lane widths.[62] Lane widths less than 12 feet on Caltrans facilities can only be used when posted speeds are less than or equal to 40 mph and average daily truck volume is less than 250 per lane.

In addition to the HDM, the Caltrans endorsement of the NACTO *Urban Street Design Guide*[63] allows NACTO information to be used in the decisionmaking process by Caltrans staff. For example, the NACTO design guide suggests that wider lanes are correlated with higher speeds (see Figure 32). This information may be used as supporting information when justifying exceptions to the HDM lane widths in appropriate contexts when supported by engineering evidence and judgments.

Figure 32: Wider Travel Lanes Are Correlated With Higher Vehicle Speeds



Source: NACTO Urban Street Design Guide

Raised Crosswalk

Source: FHWA, Traffic Calming ePrimer

A **raised crosswalk** is a raised area placed across the roadway with a flat top that is marked for pedestrian crossings, and is an example of a vertical measure for traffic calming focused on pedestrian safety. Although the main purpose of this treatment is to alert drivers about the presence of pedestrians, raised crosswalks are designed to physically limit the speed at which a vehicle can traverse the crosswalk and are intended for crossings on local streets, collectors, and in certain circumstances, an arterial street. According to CalSTA Report of Findings, raised crosswalks are considered as roadway engineering and design countermeasures that may increase safety. They bring the level of the roadway to that of the sidewalk, forcing vehicles to slow before passing over the crosswalk and providing a level pedestrian path of travel from curb to curb.[64]

While not yet a recognized design feature in the Caltrans HDM, guidance for raised crosswalks can be found in the NACTO *Urban Street Guide*[65] and on the Safe Routes to Schools website.[66] This guidance indicates that raised crosswalks can be used midblock or may be installed as a fully raised intersection. A single raised crosswalk reduces 85th percentile speeds to the range of 20 to 30 mph, and they are generally not appropriate when the pre-implementation speed is 45 mph or more. An intersection can be raised at the junction of collector and local streets and on low-speed arterials in a downtown business district with significant pedestrian activity.[67]

As agencies work to balance the proven effectiveness of engineering countermeasures to reduce operating speed with their cost, length, and complexity, it is important to note that some can be low-cost and low-intervention. These include pavement markings (e.g., lane narrowing), static signing (e.g., chevron signs), and dynamic signing (e.g., speed activated speed limit signs, speed activated warning signs).[68] For instance, research has demonstrated that speed feedback signs, which display a vehicle's current speed to remind the driver to slow down, have been effective at reducing speeds by 5 mph[69].

Curb Extensions or Bulbouts

Curb extensions are physical extensions of the sidewalk into the roadway where there is on-street parking. Curb extensions function as traffic calming elements and decrease the time and distance required for people to cross.

Curb extensions increase the visibility of pedestrians to drivers and bicyclists and also give pedestrians a better view of oncoming traffic. Curb extensions can be placed at intersections or mid-block and they can provide additional space for street furniture, landscaping, aesthetic surface treatments and curb ramps.

Curb extensions should not extend into bike lanes and should enable trucks to turn without mounting the curb. They must be designed to allow for adequate drainage (to avoid water, ice, leaf and road debris buildup) and street sweeper accessibility. In areas of regular snowfall, bulbouts must be marked by objects visible to snowplow operators. Curb extensions may be placed at mid-block locations, as is shown on a city street in Oakland where a crosswalk connects to a pedestrian crossing island.[70]

Source: Main Street, California

SPEED SUITABILITY PERFORMANCE MEASURES, ANALYSIS METHODS, AND RESOURCES		
PERFORMANCE MEASURES	**METHODS**	**RESOURCES**
Actual Speed versus Desired Speed	• Formal speed study • Speed feedback sign data collection • "Big data" sources using vehicle-based or remote cell phone sensors	• California Manual for Setting Speed Limits • Speed feedback sign data collection is an informal source; Pasadena has used it to understand the effectiveness of the signs and their designs • Big data sources are relatively new and have limited guidance
Collision Reduction – Count and Severity	• TSAR/SWITRS	• California Manual on Uniform Traffic Control Devices, Chapter 3
Pedestrian Yielding Rates, Speeding by Drivers at Crosswalks	• Experimental/decoy pedestrian crossings • Speed measurement at crosswalks	• NHTSA Pedestrian Safety Enforcement Operations: A How-To Guide

RESOURCES: IMPROVE SAFETY

- CalSTA Report of Findings: AB 2363 - Zero Traffic Fatality Task Force (2020)
  https://calsta.ca.gov/subject-areas/enforcement-and-safety/zero-traffic-fatalities
- Caltrans. Main Street, California: A Guide for Improving Community and Transportation Vitality
  https://dot.ca.gov/-/media/dot-media/programs/design/documents/main-street-3rd-edition-a11y.pdf
- NACTO Urban Street Design Guide
  https://nacto.org/publication/urban-street-design-guide/
- FHWA Traffic Calming ePrimer
  https://safety.fhwa.dot.gov/speedmgt/traffic_calm.cfm
- FHWA Achieving Multimodal Networks
  www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/
- FHWA. Proven Safety Countermeasures
  https://safety.fhwa.dot.gov/provencountermeasures/
- Caltrans. California Manual for Setting Speed Limits
  https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/2020-california-manual-for-setting-speed-limits-a11y.pdf
- NHTSA Pedestrian Safety Enforcement Operations: A How-To Guide
  https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812059-pedestriansafetyenforceoperahowtoguide.pdf

Example: Improve Safety on SR 299 in Willow Creek

> CASE STUDY AT A GLANCE

STRATEGIES

Apply Elements to Improve Safety for Pedestrian and Bicyclists

KEY TAKEAWAYS

- Rural downtowns or main streets can apply traffic calming measures to create a pedestrian and bicycle friendly environment.
- Improve safety and livability in rural downtowns.
- Districts can apply for grant funding for -bicycle and pedestrian- safety projects

RESOURCES

- Caltrans. Complete Streets Program https://dot.ca.gov/programs/transportation-planning/office-of-smart-mobility-climate-change/smart-mobility-active-transportation/complete-streets

Willow Creek is a small town in Humboldt County, 40 miles east of Arcata. State Route 299, known as Trinity Highway, runs through Willow Creek and serves as the town's main street. Concerned with high traffic speeds through town, residents initially requested lowering the posted speed limit from 45 mph to 35 mph throughout the commercial area (as opposed to one central segment). However, because an engineering and traffic survey showed actual traffic speeds to be higher than the posted limit, reducing the posted speed limit and enforcing the new limit would be difficult under California laws.

Caltrans District 1 applied for and received grant funding from the Transportation Enhancements fund, and in coordination with a repaving project, implemented a road diet project in Willow Creek. The project, completed in 2004, consisted of converting four traffic lanes and a center turn lane to two traffic lanes plus a turn lane. The remaining right of way was used to create bicycle lanes and vehicle parking.

Figure 33: Improve Safety on SR 299

Source: California Department of Transportation

Example: SR 49 & Main Street Roundabout in Plymouth

> CASE STUDY AT A GLANCE

STRATEGIES

Apply Elements to Improve Safety for Pedestrian and Bicyclists

KEY TAKEAWAYS

- Roundabouts can improve traffic flows and improve safety by reducing conflict points.
- Roundabouts can serve as gateway treatments where intersection control is warranted in towns with high weekend, holiday, and seasonal traffic.

RESOURCES

- City of Plymouth Public Works and Transportation webpage http://cityofplymouth.org/publicworks-transportation.html
- HDM Chapter 400

Plymouth is considered the gateway to Amador County wine country. State Route (SR) 49 is a historic state route stretching the length of California Gold Country. In Plymouth, SR 49 previously intersected with Main Street at a skew, with no bicycle or pedestrian facilities. The overall crash rate at the intersection was three times the state average for similar two-lane highways.

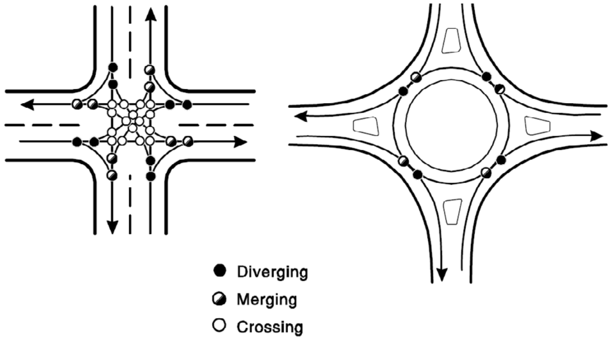
The City of Plymouth, the lead agency for this project, identified seven priorities for an intersection redesign: improve safety; increase corridor capacity; increase corridor throughput; stimulate the local economy, especially in close proximity to SR 49 & Main Street; improve operations; improve pedestrian and bicycle facilities; and meet current standards. To address these priorities, the city developed a plan for a roundabout with marked crosswalks at the intersection site. Roundabouts have been shown to reduce serious crashes and injuries by reducing the number of conflict points at the intersection. See Figure 35.Construction was completed in 2018.

Roundabouts are a relatively new type of design in California, though used elsewhere in the United States and internationally. To help the public and new users become accustomed to the new design, the project team created a temporary traffic flow during construction, similar to a roundabout, with signage and flaggers to help drivers learn how to move through the new space.

Figure 34: Plymouth Roundabout

Source: City of Plymouth

Figure 35: Conflict Points in a Traditional Intersection Compared to a Roundabout



Source: NCHRP. Roundabouts: AN Informational Guide

Example: Pasadena Speed Management

> CASE STUDY AT A GLANCE

STRATEGIES

Improve Safety for Pedestrian and Bicyclists, Apply Traffic Calming Elements

KEY TAKEAWAYS

- Consider traffic signal coordination, reduced travel lane width, speed enforcement corridors and speed feedback signs on roads with over 20,000 vehicles per day to reduce speeds.
- Consider road diets, single lane roundabouts, and raised intersections on roads with fewer than 20,000 vehicles per day to reduce speeds (in addition to the elements for higher volume streets).

RESOURCES

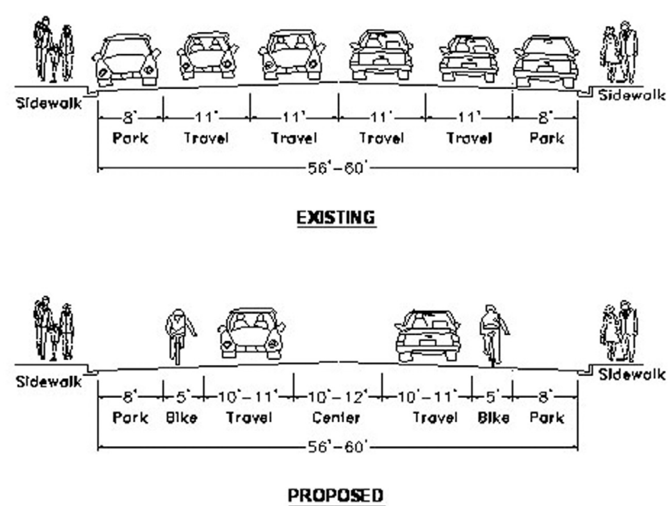
- City of Pasadena. Pasadena Street Design Guide https://ww5.cityofpasadena.net/transportation/wp-content/uploads/sites/6/2017/05/Pasadena-Design-Guidelines-3-22-17.pdf
- City of Pasadena. Best Practices in Arterial Speed Management http://ww2.cityofpasadena.net/trans/TAC%20REPORTS/2009/110509/ITEM_4B_110509_TAC.pdf
- Caltrans. Effective Application of Traffic Calming Techniques

The City of Pasadena has been actively engaged in implementing a speed management policy on their larger streets for almost 10 years, and has seen the benefits of this work realized. In 2008, Pasadena commissioned a report on "Best Practices in Arterial Speed Management," which recommended different approaches to speed management for streets based on average daily traffic volumes. On streets with greater than 20,000 vehicles per day, the recommended speed management measures included signal coordination, reduced travel lane width, speed enforcement corridors, and speed feedback signs that flash "Slow Down" when speed exceeds a preset limit. On streets with fewer than 20,000 vehicles per day, the report recommended many of the same measures as high vehicle volume streets, plus measures such as road diets, single-lane urban roundabouts, and raised intersections.

Since that 2008 report, Pasadena has worked to implement the recommended measures on arterial and residential streets. The city commissioned a review of five road diets in 2011 and found that all of the streets had reduced crash rates compared to the before period. On the only corridor where the city had before and after speed data for a road diet, the corridor speeds were reduced by up to 3 mph. And according to several unpublished local studies, speed feedback signs have reduced average vehicle speeds by 2-3 mph. These reductions have been important, especially when Pasadena performs speed studies to set enforceable limits on their streets. This highlights the critical links between road design, speed setting, and enforcement.

Pasadena has started to reach a limit in its efforts to reduce speeds on arterial roads because residents are concerned that traffic will divert to local streets. In these cases, the city typically implements speed feedback signs on the arterials as a first measure. Pasadena works closely with residential groups in their speed setting and residential road redesign efforts, while continuing to implement these ideas. The city also published a Pasadena Street Design Guide in 2017 to direct their future design efforts.

Figure 36: Road Diet Design for Cordova Street, Pasadena CA



Source: City of Pasadena

4. Accessibility and Connectivity Strategies

1. PRIORITIZE MODES WITH GRIDDED AND LAYERED NETWORKS
2. EVALUATE ACCESSIBILITY
3. EVALUATE CONNECTIVITY

About Accessibility and Connectivity

The Smart Mobility Framework principle of Location Efficiency calls for the integration of transportation and land use to achieve high levels of accessibility to destinations. Locating a variety of land uses in close proximity creates the opportunity to build transportation networks that support active travel and transit use because average trip lengths are short and do not require high-speed vehicle travel. When transportation networks provide multiple modal choices for accessing destinations, the land uses have high levels of accessibility and connectivity, improving neighborhood livability and reducing VMT.

Accessibility is the ability to reach destinations of value. Different from mobility (the potential for movement), accessibility is the potential for interaction. Good accessibility can be characterized by:

- Destinations close by
- Choice of destinations
- Choice of modes

Connectivity is the interconnection of local networks with suitable accommodation for modes most appropriate to the land use served to reduce auto dependency and trip lengths. High connectivity supports smart mobility because it means more route choices between a given origin and destination. For drivers, connectivity can reduce congestion because it allows traffic to move along a number of different routes instead of being funneled onto a single route. For pedestrians and bicyclists, higher connectivity provides more direct route options and options to avoid heavy or dangerous traffic. Higher connectivity also improves access to possible activity destinations.

Accessibility and connectivity are different from mobility. Mobility is the ease of moving on the network, characterized by minimal delay and predictable travel times. A transportation network or region may have high levels of mobility without high levels of accessibility or connectivity.

Source: California Department of Transportation

Land Use and Design Impacts on VMT

Accessibility and connectivity are closely linked to land use and have strong effects on VMT. Even without changing the transportation system, accessibility can be improved when land development results in destinations (e.g., jobs, retail, services) that are located closer to residences. Vertical and horizontal mixed-use development is a proven approach to improving accessibility. Empirical research shows that areas with better accessibility have lower VMT. A meta-analysis of literature on this topic concluded that doubling accessibility to jobs by automobile is associated with a 20 percent reduction in VMT on average.[71] Similarly, neighborhoods with higher density and greater land use mix exhibit lower VMT per household.

Better street connectivity has also been shown to reduce VMT. A well-connected street network reduces the length of a trip between two points, and also typically improves modal options – both of which tend to reduce VMT. Empirical research supports these conclusions; a meta-analysis of the literature conducted by University of California researchers found that doubling street connectivity is associated with a 8 percent to 19 percent reduction in VMT.[72] Chapter 7 discusses the combined effects of land use and design on VMT as illustrated through a series of place types.

The effects of land use, accessibility, and connectivity on travel are inherent in the location efficiency principal summarized in Chapter 1. Places with a high degree of regional accessibility and strong community design (which encompasses connectivity) show the greatest smart mobility benefits, including lower VMT.

The effects of accessibility and connectivity on VMT are particularly important due to the requirements of SB 743 (2013) and SB 375 (2008). SB 743 is changing CEQA transportation analysis by replacing level of service (LOS) with VMT as the measure of impact on the transportation system. SB 375 requires that Regional Transportation Plans achieve vehicle GHG reduction targets established by the California Air Resources Board, which largely relies on VMT reductions. Because of these requirements, high-level state goals and regional targets for GHG reduction can be better tied to corridor and local planning and funding decisions.

VMT is a composite metric that is influenced by land use patterns, population and employment growth, the transportation network, human behavior, and other factors. For example, an increase in economic activity caused by rising employment or trade could generate new vehicle trips and higher VMT. VMT is also affected by travel costs; higher fuel prices will discourage automobile travel, for example. Larger demographic trends, such as a delay in the typical age of obtaining a driver license, or increasing driving by seniors, can also influence VMT. Additionally, the availability of transit and other modal options plays a role in VMT trends.

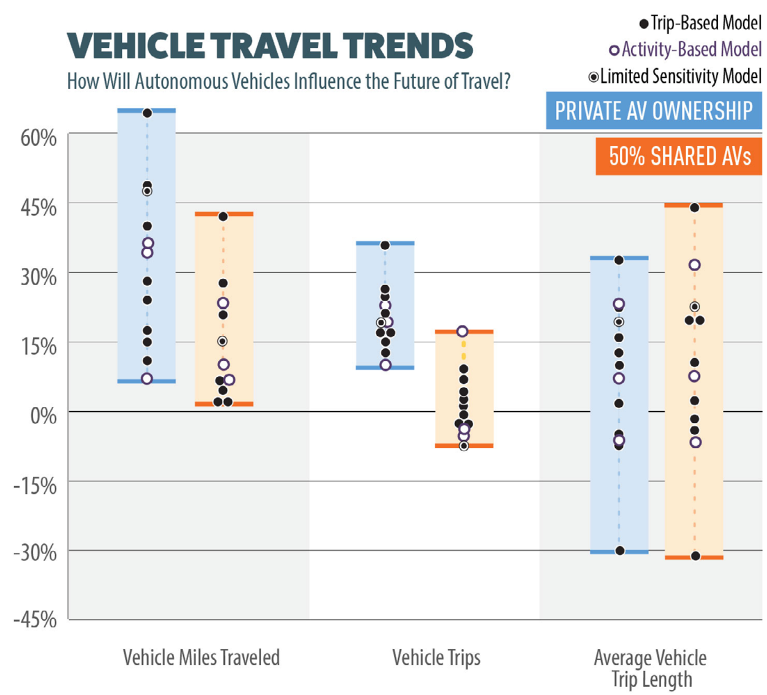
A key challenge for analysts to address when using VMT-related metrics is how disruptive trends such as transportation network companies (TNCs), autonomous vehicles (AVs), and internet shopping will influence future conditions. VMT generation rates are not static over time but increase and decrease as noted above. Hence, they may increase or decrease depending on how technology (and government regulation) affect mobility especially in regards to the cost of vehicle travel. As highlighted below, the State of California Automated Vehicle Principles for Healthy and Sustainable Communities captures this uncertainty.[73]

Automated Vehicle Principles for Healthy and Sustainable Communities

The deployment of AVs will likely lead to a once-in-a-century transformation of our transportation system and our communities. California has the opportunity to exercise proactive leadership to steer this transformation towards the public benefit. With a clear policy framework to guidedeployment, AVs could create a transportation system that gets people to destinations more quickly and provides more and better travel options, decreases greenhouse gas and criteria pollutant emissions, improves safety of all road users, encourages efficient land use, enhances public health, and improvestransportation equity and economic opportunity. However, without attention to the broader environmental implications of AV deployment, AVs could increase congestion, commute times, vehicle miles traveled (VMT), and emissions of GHGs and other air pollutants; induce additional sprawl; increase poor health outcomes, and exacerbate social inequities.

Current research on AV effects demonstrate the potential for substantial increases in VMT due to vehicle travel becoming less expensive in terms of time (i.e., act of driving no longer required) and money while also becoming more convenient with the elimination of parking. Figure 37 shows the forecasted increases in vehicle travel under a 100 percent AV fleet without new government regulation. These forecasts were produced using 10 regional travel forecasting models from around the U.S. The forecasts generally represent 20-year horizon. The blue columns show the effects presuming AVs are owned as passengers cars are today. The orange columns presume that 50 percent of drive alone trips shift to a shared ride. Even with a large number of shared trips, VMT increases above the non-AV scenario. Since MPO compliance with SB 375 GHG targets is predicated on reducing VMT generated per capita, these results highlight the importance of considering AV effects.

Figure 37: Vehicle Travel Trends

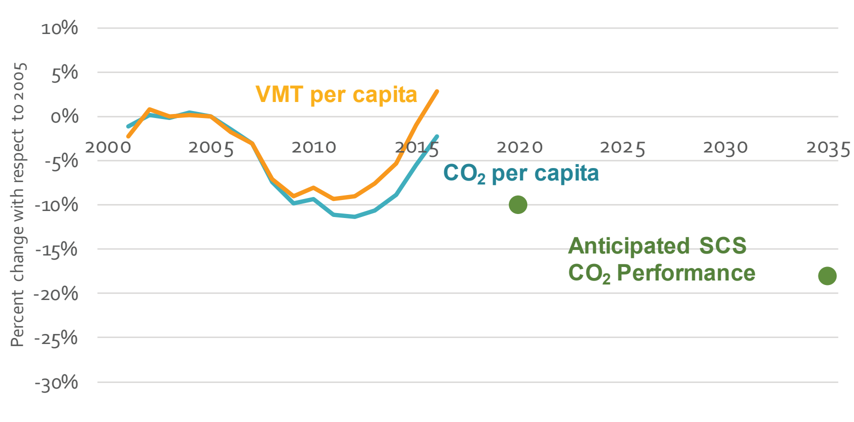


Source: Fehr & Peers

Any use of VMT related metrics should acknowledge forecasting limitations due to economic, demographic, and disruptive trends. When appropriate, VMT analysis should attempt to quantify the influence of disruptive changes. This is particularly important when relying on regional MPO travel forecasting models developed for regional transportation plan/ sustainable community strategies. As documented in CARB's 2018 Progress Report, California's Sustainable Communities and Climate Protection Act, MPO forecasts of declining VMT and GHGs per capita do not match the reality of increasing VMT and mobile emissions of GHG emissions per capita.

With MPO models serving as one of the most common sources of forecasts for traffic volumes, transit ridership, and VMT used in regional plans, local general plans, project development studies, and CEQA/NEPA compliance, these models should not be used "off the shelf" without verifying the reasonableness and sensitivity of the model's forecasts.

Figure 38: Statewide CO2 and Vehicle Miles Traveled (VMT) Per Capita Trend with Respect to Anticipated Performance of Current SB 375 SCSs



Source: California Air Resources Board 2018 Progress Report

STRATEGY AT A GLANCE

4.1 PRIORITIZE MODES WITH GRIDDED NETWORKS AND LAYERED NETWORKS

STRATEGY SUMMARY

- ❑ Assign modal priority for segments in a plan based on factors such as critical connections for each mode, level of comfort, relationship to land use.
- ❑ Use assigned modal priorities for each segment to determine investment needs for those segments.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- Alameda Countywide Multimodal Arterial Plan https://www.alamedactc.org/planning/countywide-multi-arterial-plan/
- ITE. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach https://www.ite.org/pub/?id=E1CFF43C-2354-D714-51D9-D82B39D4DBAD

4.1 PRIORITIZE MODES WITH GRIDDED NETWORKS AND LAYERED NETWORKS

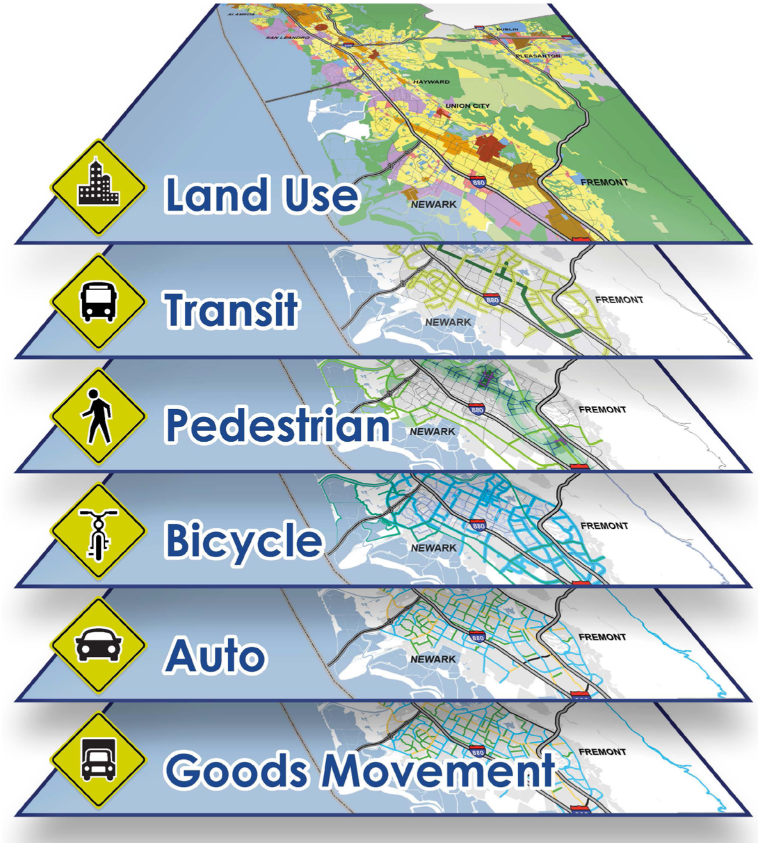
Layered networks can increase accessibility and connectivity. Both layered networks and complete streets contribute to these characteristics, but accommodate transportation modes differently. Complete streets seek to incorporate all modes (autos, transit, bicycles, pedestrians, trucks) into the right-of-way. However, in a system of layered networks, pedestrian, bicycle, auto, and transit modes have priority on different segments of the network depending on land use context, thus reducing the potential conflict inherent in trying to design all roadways for all uses. As shown in Figure 39, complete networks are required for each mode of transportation to connect the various land use destinations in a community.

When determining modal priority for roadway segments, planners should consider:

- What are the land uses that the segment serves?
- What is the relationship between the segment and adjacent buildings?
- What connections does the segment create for each mode?
- What is the experience (including delay and comfort) for each mode on the segment? How does the segment function for each user?
- Would improving the user comfort for a mode provide better connectivity or accessibility?
- What alternative segments are available for each mode?
- How are needs for each mode balanced across the networks?

After priorities for each segment are identified, the level of investment corresponding to each mode can be determined. Figure 40 is an example from one jurisdiction of how investment may vary depending upon the priority for each mode.

Figure 39: Layered Network



Source Alameda Countywide Multimodal Arterial Plan

Figure 40: Transit Modal Priority

ARTERIAL AND COLLECTOR STREET DESIGN CONSIDERATIONS

Transit Modal Priority

STREET ZONE	DESIGN CONSIDERATIONS
PEDESTRIAN	▪ Provide a wider Pedestrian Zone to allow more room for pedestrians to wait for, board, and alight transit vehicles
CURB	▪ Provide a wide Curb Zone to accommodate bus stops, including furniture and wayfinding kiosks for better transit accessibility for pedestrians
BICYCLE	▪ It is recommended to provide a bicycle facility such as a Class II Bike Lane, although a bicycle zone is not required ▪ Consider a protected bikeway facility to minimize bus and bicycle weaving
VEHICLE	▪ Provide a wider Vehicle Zone to allow wider outside travel lanes to accommodate and allow for dedicated bus-only/rapid transit lanes, bus bulbs, and bus pull outs
MEDIAN	▪ Where a median is present, provide a wider median to allow for transit turning movements
CROSSING	▪ Design corner treatments with a large curb radius to allow for transit turning movements in the outer travel lanes, while still accommodating emergency vehicle access and street maintenance. ▪ Provide pedestrian refuge islands at pedestrian crossings ▪ Frequently space crossing opportunities with crosswalks at all stops

RELEVANT DESIGN STANDARD DETAILS					
Bus Stops	p. 3-9	Class II Bike Lanes	pp. 3-20 to 3-27	Dedicated Bus-only Lane	p. 3-45
Bus Bulb	p. 3-17	Bus Pull-out	p. 3-16	Corner Treatments	p. 3-52
Pedestrian Refuge Island	p. 3-49				

Source: Central County Complete Streets Design Guidelines, Alameda County Transportation Commission

Gridded networks can be used to create transportation systems with high levels of connectivity. The following figures for Landsdale, PA and Montgovermyville, PA, illustrate the higher degree of connectivity with a traditional gridded network.

Figure 41: Traditional Grid Roadway Network, Landsdale, PA

Gridded street networks, common to many cities developed before the automobile, provide multiple alternative routes between destinations; if one link or intersection has delays, traffic can use parallel links or other routes. Shorter distances between destinations also encourage walking and bicycling. These networks are characterized by short block lengths and a mix of land uses.

Figure 42: Auto-oriented Road System, Montgomeryville, PA

Auto-oriented road systems route traffic through limited connections. Although such systems reduce cut-through traffic in neighborhoods, they also concentrate traffic, often producing bottlenecks and congestion. Longer distances between destinations discourage walking and bicycling. These systems are also characterized by segregated and isolated land uses.

STRATEGY AT A GLANCE

4.2 EVALUATE ACCESSIBILITY

STRATEGY SUMMARY

- ❑ Use change in VMT per capita as a proxy for measuring accessibility in travel forecasting when developing a project.
- ❑ Use elasticity methods (such as comparing VMT variations in comparable situations) to estimate impacts of a proposed project on VMT if travel forecasting is not available.
- ❑ Measure the number of destinations or jobs available within a maximum travel time instead of delay, travel speed, or travel time between destinations, which emphasizes accessibility over mobility.
- ❑ Measure VMT change per capita for a specific area, given a proposed project, rather than VMT per capita specifically generated by the project.

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- Caltrans improved data and tools for integrated land use-transportation planning
  http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-use-transportation-planning-california
- EPA Smart Location Database
  https://www.epa.gov/smartgrowth/smart-location-mapping#SLD

4.2 EVALUATE ACCESSIBILITY

Source: California Department of Transportation

Change in VMT per capita is an effective measure of accessibility. While VMT is directly related to vehicle travel, expressing the variable in a per capita format and measuring the change allows it to serve as a measure (or proxy) for land use proximity and the effect on other modes of travel. Typically, for VMT per capita to decrease, trips have to shift to other modes such as walking and bicycling, or vehicle trip lengths have to shorten, or both. This occurs when land uses are concentrated and mixed or the network is modified to improve the effectiveness of walking, bicycling, or using transit (i.e., better accessibility).

If an adequate travel forecasting model is not available to measure VMT, elasticity methods can be used to estimate the effect of a project on regional VMT. The simplest approach for screening is to observe VMT variations in comparable situations with respect to place type and transportation network availability.

The performance measures table at the end of this section also includes performance measure alternatives to VMT, including jobs or other destinations available within a particular travel time, origin-destination travel times, and overall delay. These measures can be estimated using GIS tools, existing data such as observed travel speeds, and other methods.

Evaluate Jobs/Other Destinations Within X Minutes of Travel Time by Mode

By measuring the number of destinations available within a maximum travel time instead of delay, travel speed, or travel time between destinations, these performance measures emphasize accessibility over mobility. Destination accessibility can be analyzed using GIS tools and local sources such as travel demand models. Travel networks are readily available for automobiles and frequently available for other modes from sources such as the General Transit Feed Specification. Simple analysis may be conducted using constant travel speeds for each mode, while more detailed analysis may be developed using congested or historical travel speeds by segment.

Evaluate Change in VMT Per Capita from Base Value

By evaluating the change in VMT for a specified study area, the impact of a project on VMT may be assessed (thus identifying overall VMT reductions or increases), rather than solely considering the VMT generated by a project by itself, which would not consider the effect of a project on a region. This measure may be best analyzed using a travel demand model, but, if a model is not available or appropriate, also may be estimated using a land use and transportation analysis software, such as UrbanFootprint, or by using elasticity methods. The UC Davis example discussed later in this chapter illustrates an application of this type of analysis.

Source: California Department of Transportation

STRATEGY AT A GLANCE

4.3 EVALUATE CONNECTIVITY

STRATEGY SUMMARY

- ❑ Use checklists or simple factor analysis tools, such as the EPA Smart Location Database, regarding the transportation network pattern and suitability for different modes
- ❑ Analyze highway permeability, especially in relation to bicycle and pedestrian movements. Highways in particular can be barriers for local movement and impact the connectivity of an area
- ❑ Measure density of intersections in a given area

WHERE IN THE PROCESS TO APPLY

Planning → Project Initiation → Project Development → Operations & Maintenance

RESOURCES

- Caltrans improved data and tools for integrated land use-transportation planning: http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-use-transportation-planning-california
- EPA Smart Location Database https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
- FHWA Guidebook for Measuring Multimodal Connectivity https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/

4.3 EVALUATE CONNECTIVITY

Connectivity can frequently be measured with checklist or simple factor analysis tools (such as the EPA Smart Location Database), as shown in the performance measures table at the end of this section. Some built environment variables, especially intersection density, have strong relationships with connectivity and are thus good measures.[74] Percentage of sidewalks and painted crosswalks are good indications of pedestrian connectivity, specifically. Similarly, bicycle level of traffic stress can be estimated and used to measure the connectivity of bicycle networks.[75]

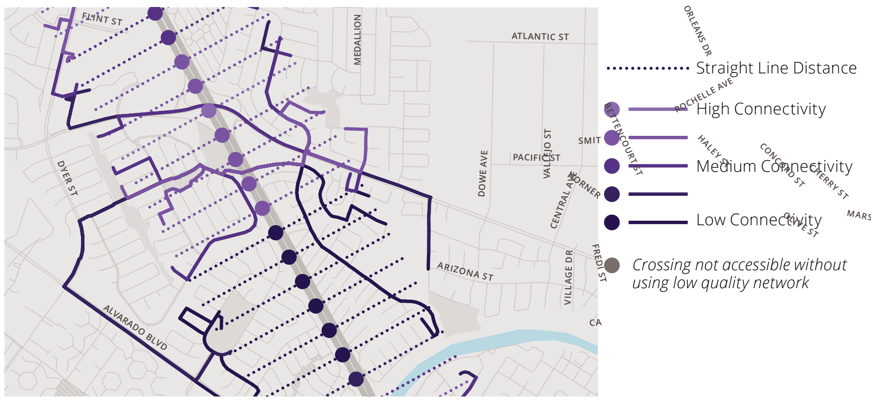
Generally, local data is best for this analysis, but if local data is not available, other datasets and tools can help. UrbanFootprint, an urban planning software now available for free to jurisdictions in California, has data available for much of the state. The EPA Smart Location Database is another source of data for a variety of factors, including intersection density.

Evaluate Highway Permeability and Bicycle Network Connectivity

Connectivity can be evaluated in terms of the effects of a highway on local network movement. Highways can generate mobility barriers for local travelers in the communities they bisect, particularly pedestrians and bicyclists. Highways that prohibit non-motorized travel are “hard barriers” of physically impassible space that require prohibited travelers to find routes around them. Highway ramps also act as barriers, or at least very high-stress crossings. Highways that allow non-motorized travelers to share travel lanes with fast-moving vehicles along the corridor or at designated crossings present “soft barriers,” or factors that deter non-motorized travel. In addition to lack of bike lanes, factors such as poor lighting at undercrossings, large intersections with many lanes of traffic to traverse, high-speed turning vehicles, or roadways with narrow shoulders or with adjacent walls can all create soft barriers. In these settings, bicyclists and pedestrians are not forced to find a way around the road, but they can experience high stress levels while crossing the corridor if the roadway is not designed to provide them with clearly designated, safe, and conveniently located paths.

Highway permeability can be evaluated by calculating the route directness for a sample of hypothetical origin and destination points placed on either side of the highway. Each origin-destination point is linked to the nearest point on the local road network. Straight-line distances are calculated between each origin-destination pair, representing the most theoretically direct route across the state highway. To establish a comparative context for the theoretical straight-line distance assessment, a GIS-based network analysis is used to calculate the shortest route across the state highway between each origin and destination along the actual road network, as illustrated in Figure 43.

Figure 43: Analysis of Bicycle Connectivity Across a State Highway



Source: FHWA Guidebook for Measuring Multimodal Connectivity

Another way to evaluate highway permeability is by analyzing the directness of a route based on a number of variables using a GIS tool called the Route Directness Index. The Route Directness Index can be calculated as the ratio between straight-line theoretical distances and actual roadway network distances between origins and destinations on opposite sides of the state highway. Low-scoring routes are the most direct. Higher scores indicate the need for bicyclists to navigate substantially out of the most direct path to avoid a stressful or impassible area. Mapping the Route Directness Index scores along the highway provides a high-level indication of connectivity throughout the corridor.

This concept can be applied to map connectivity to a particular destination. Figure 44 illustrates the lack of intersections through the main corridor creates low connectivity to destinations in the northeast portion of the map.

The Caltrans District 4 and American River Crossing examples in this chapter provide additional examples of this type of analysis.

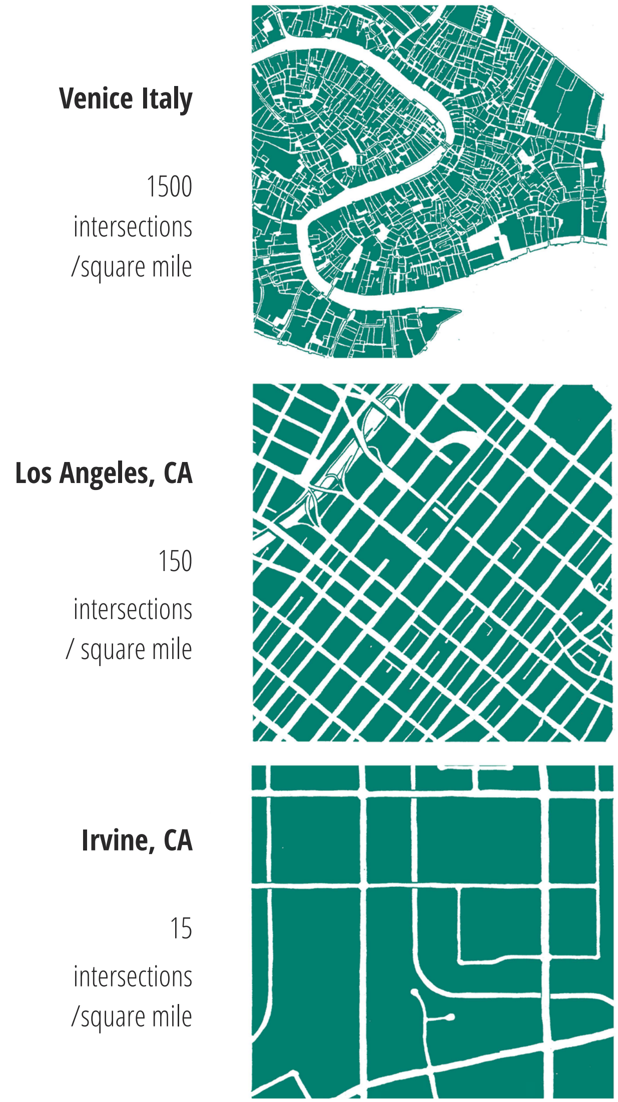
Figure 44: Example of Lack of Connectivity

Source: ESRI. Transportation Connectivity and Accessibility Analysis StoryMap.

Evaluate Intersection Density

Intersection density can be used as a simple measure of connectivity. As discussed in the Gridded and Layered Networks section, a highly-connected roadway network with a large number of links and intersections provides many available routes to get from one place to another and reduces distances between destinations. In some contexts, supplemental diagonal routes or other main connections, especially between major destinations, can support connectivity and reduce trip length. GIS tools can readily be used to estimate this metric. Figure 45 compares street networks at the same scale, visually showing how connectivity varies by the order of magnitude of the intersection density.

Figure 45: Comparison of Intersection Density in Selected Cities



Source: Allan B. Jacobs. Great Streets

ACCESSIBILITY PERFORMANCE MEASURES, ANALYSIS METHODS, AND RESOURCES		
PROJECT SCALE	**PERFORMANCE MEASURES**	**METHODS AND RESOURCES**
SINGLE PROJECT	• Jobs within 20 minutes by auto, 30 minutes by transit • Jobs within 3 bike network miles • Other destinations within 10 minutes by auto, 20 minutes by transit, 3 miles by biking, ½ mile by walking • Change in VMT per capita from base value	• GIS map path traces • Data and suppliers such as General Transit Feed Specification (GTFS), PeMS, INRIX • EPA Smart Location Database (SLD) • Travel model network skim matrices and zonal socioeconomic data • Induced travel elasticities
LOCAL NETWORK	• Change in VMT per capita from base value	• Caltrans improved data and tools • EPA SLD indicators • Induced travel elasticities
LARGE AREA SYSTEM	• Change VMT per capita, mode share or SOV rate from base value • Change in network delay • Weighted regional travel time among trip producers and attractors • Change in jobs and other destinations within target times for total travel and equity subgroups • Travel time between representative origin-destination pairs	• UrbanFootprint or similar software • Caltrans statewide or regional travel models

CONNECTIVITY PERFORMANCE MEASURES, ANALYSIS METHODS, AND RESOURCES		
PROJECT SCALE	**PERFORMANCE MEASURES**	**METHODS AND RESOURCES**

SINGLE PROJECT	• Intersection density, i.e. number of intersection per square mile
	• Transit route directness
	• Low stress bike network gap closures
	• Layered network completeness including:
	    • Suitable-speed network
	    • Transit priority network
	    • Low stress bike network
	    • Pedestrian network
	    • Freight network
		• EPA Smart Location Database (SLD)
		• Urban Footprint data
		• Available local modal maps

LOCAL NETWORK OR LARGE AREA SYSTEM	• Layered network completeness/gaps • Suitable-speed network density • Transit priority network density • Low stress bike network density • Pedestrian network completeness/gaps • Travel time between representative origin/destination pairs, by mode • VMT reduction based on intersection density	• Available local modal maps • Urban Footprint data • If these sources are not available, Caltrans integrated planning tools and EPA SLD for intersection density

RESOURCES: ACCESSIBILITY AND CONNECTIVITY PERFORMANCE MEASURES

- EPA Smart Location Database
  www.epa.gov/smartgrowth/smart-location-mapping
- CARB Impact of Highway Capacity and Induced Travel on Passenger Vehicle Use and Greenhouse Gas Emissions Policy Brief (2014): www.arb.ca.gov/cc/sb375/policies/hwycapacity/highway_capacity_brief.pdf
- OPR Technical Advisory on Evaluating Transportation Impacts in CEQA
  http://opr.ca.gov/ceqa/updates/sb-743/
- Caltrans improved data and tools for integrated land use-transportation planning
  http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-use-transportation-planning-california
- FHWA Guidebook for Measuring Multimodal Connectivity
  https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/

RESOURCES: ACCESSIBILITY AND CONNECTIVITY PLANNING AND DESIGN

- ITE. Planning Urban Roadway Systems. 2014.
  https://ecommerce.ite.org/IMIS/ItemDetail?iProductCode=RP-015D
- Caltrans Director's Policy on Context Sensitive Solutions (DP-22)
- Caltrans Deputy Directive on Complete Streets (DD-64-R2)
- University of Minnesota Accessibility Observatory
  http://access.umn.edu/

Example: Bicycle Connectivity Across Highways, Caltrans District 4

> CASE STUDY AT A GLANCE

STRATEGIES

Evaluate Connectivity

KEY TAKEAWAYS

- Planners can analyze impacts of highways on bicycle networks by using Route Directness Indices, which measures distances between origins and destinations accessible by bicycle, identifying barriers leading to long detours for bicyclists.
- A bicycle route directness analysis includes a Level of Traffic Stress (LTS) analysis to identify low-stress routes for bicycling. This LTS analysis framework can be modified for a variety of analysis priorities and goals.

RESOURCES

- Caltrans District 4 Bike Plan. 2017. California Department of Transportation.
- Openstreetmap.org
- FHWA Guidebook for Measuring Multimodal Connectivity https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/

As part of bicycle master plan for District 4, Caltrans evaluated the barrier effects of state highways within the context of local multimodal networks in order to identify locations with poor bicycle connectivity. Because interchange spacing is often a mile or more in urban areas, freeways create longer distances between origins and destinations making bicycling or walking inconvenient. Four highway corridors were evaluated: I-680 in Contra Costa County, I-880 in Alameda County, US 101 in Marin County, and SR 121 in Napa County. The methodology involved calculating bicycle route directness for a sample of hypothetical origin and destination points placed on either side of the highway. Sampling points were placed every 500 feet along the highway, regardless of whether the location is a highway crossing. The origin and destination points were placed on either side of the highway 1/3 mile away from and perpendicular to the associated sampling points. The local road network included all publicly accessible roadways within 1.5 miles of the state highway that are available for use by bicyclists.

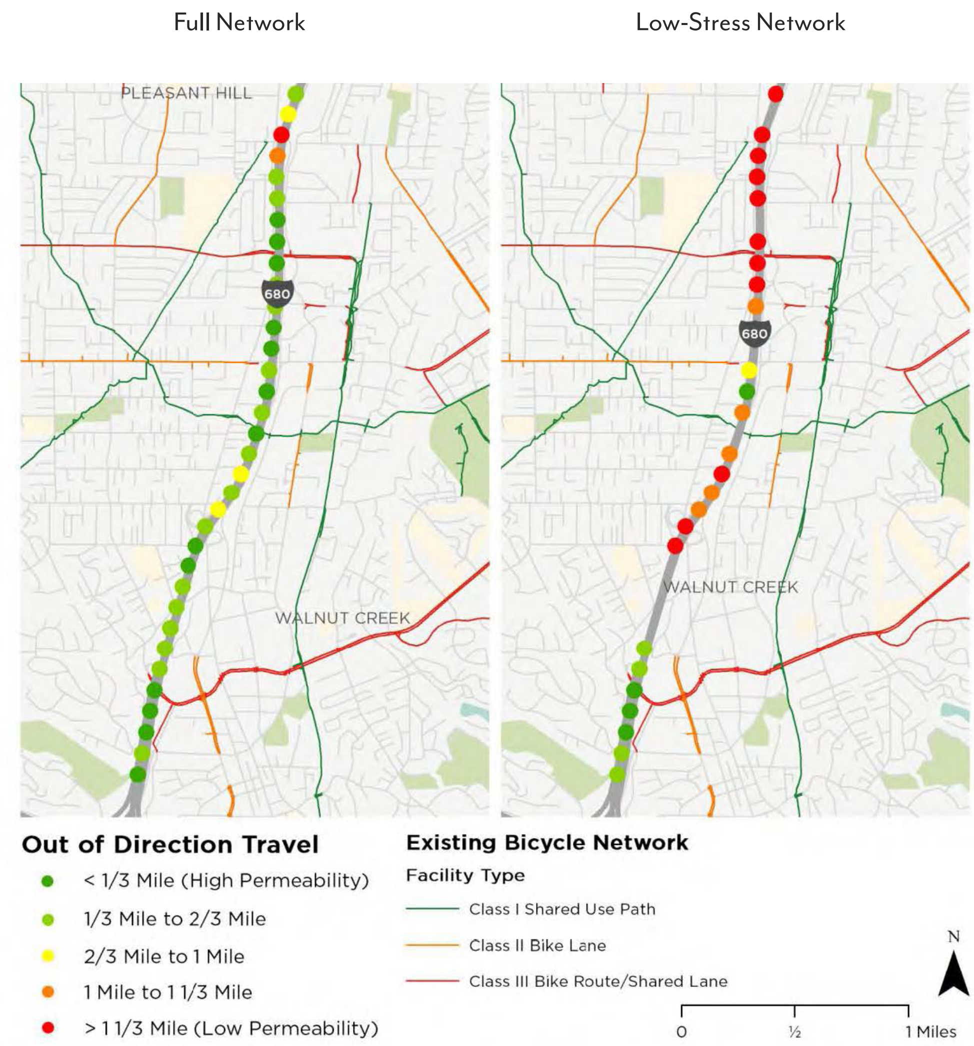
The primary data source for the evaluation was OpenStreetMap (OSM). OSM is an openly available crowdsourced map of the world with geospatial data on transportation networks and other map features. Because the currently available state GIS attribute data for highways lacks some significant information about various roadway characteristics that were important for the District 4 Bicycle Plan, the OSM network for this analysis was merged with Caltrans' Functional Roadway Classification data and with local bikeway data collected from the nine counties in the region.

The analysis determined the Level of Traffic Stress (LTS) for each segment and crossing of the state highway system. Because the LTS analysis framework is organized around roadway segments, a unique methodology was developed to evaluate LTS at highway crossings, including conventional, surface highway intersections and ramps to access-controlled facilities. The approach to defining LTS for crossings is the same as that applied to roadway segments: the LTS score is linked to the type of user that would feel comfortable using the facility.

Figure 46 shows maps of Route Directness Indices for a portion of I-680. The left map shows the results considering the full roadway network while the right map shows results for a "low stress" network, excluding arterial streets. When considering all available routes, the Route Directness analysis shows a high permeability along much of the I-680 corridor. For this network, much of the corridor has a Route Directness Index between 1 and 2, indicating that crossing the freeway requires users to travel out of their way by up to two times the straight-line distance between the two sides.

Permeability is reduced when routes are restricted to a "low stress network" that excludes arterial streets. Although several permeable crossings are present along this corridor, most crossings require users to travel out of their way by distances two to four times longer than the straight-line distance between the two sides. Research suggests that for trips under 1 mile, a low-stress route should be less than .3 miles longer than the most direct (but higher stress) route. For longer trips, the low-stress route should be less than 25 percent longer than the most direct route.[76]

Figure 46: Highway Permeability Study for Contra Costa



Source: FHWA Guidebook for Measuring Multimodal Network Connectivity

Example: American River Crossing Alternatives Study

> CASE STUDY AT A GLANCE

STRATEGIES

Evaluate Accessibility, Evaluate Connectivity

KEY TAKEAWAYS

- Using GIS to identify destinations by walking or bicycling can compare alternatives for barrier crossings (in this case, a river).
- Analyzing accessible destinations considers not just conditions of individual roads, but also their role in the greater non-motorized network.

RESOURCES

- City of Sacramento. American River Crossings Study
- Caltrans improved data and tools for integrated land use-transportation planning http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-use-transportation-planning-california
- FHWA Guidebook for Measuring Multimodal Connectivity https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/

This study was initiated to fulfill the Sacramento General Plan policy aimed at overcoming the natural barrier that the American River between I-5 and State Route 160 creates for travel between South Natomas and the River District of Sacramento. The project was a holistic look at access, mobility, and the economy. Stakeholder values drove the prioritization of the alternatives analyzed. The study incorporated methodologies representing different levels of accessibility and connectivity analysis. The images here show an example of a project scale accessibility analysis for two potential crossing locations, using GIS to identify destinations within ½ mile by walking for each project alternative. Alternative 3 provides more pedestrian access than Alternative 2, as demonstrated in the adjacent images.

Eight feasible alternatives were identified based on existing constraints such as sensitive environmental habitat, existing utilities, and land uses. Alternatives included expansion of existing bridges to add bicycle and pedestrian connections and new multimodal bridges. Community values were reflected in the performance criteria. Physical areas being served for each mode were identified. After comparing each alternative to the criteria and performing a high-level environmental analysis, preferred alternatives were identified. The analysis showed that by improving connectivity, the improved alternatives increased access for each mode and reduced vehicle trips and trip lengths.

Figure 47: Alternative 2: American River Crossing

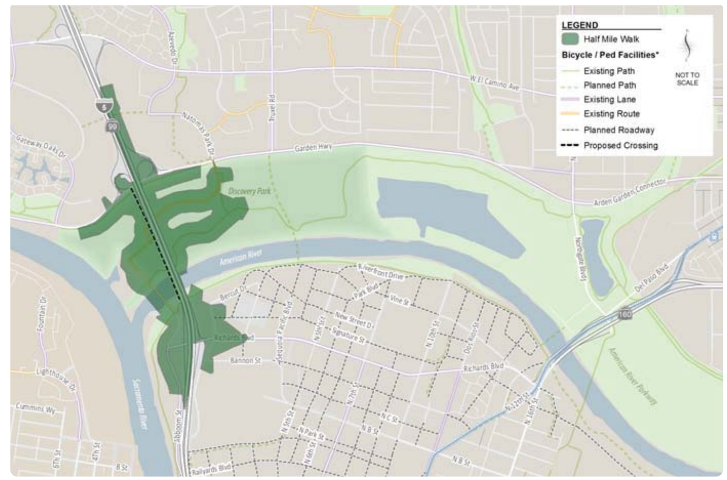
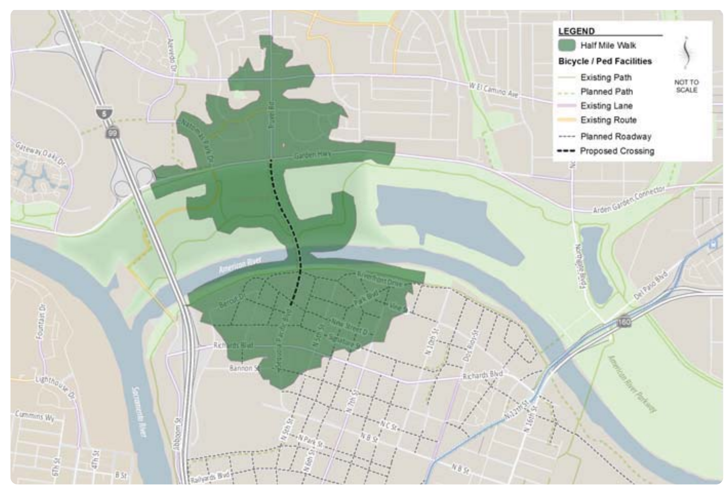


Figure 48: Alternative 3: American River Crossing



Source: City of Sacramento Summary Report for American River Crossing

Example: Stockton Bicycle Master Plan

> CASE STUDY AT A GLANCE

STRATEGIES

Evaluate Bicycle Level of Traffic Stress

KEY TAKEAWAYS

- Use a Bicycle Level of Traffic Stress Analysis to create a network plan to address gaps in the bicycle network in a given area.
- Use multimodal metrics in project prioritization criteria.

RESOURCES

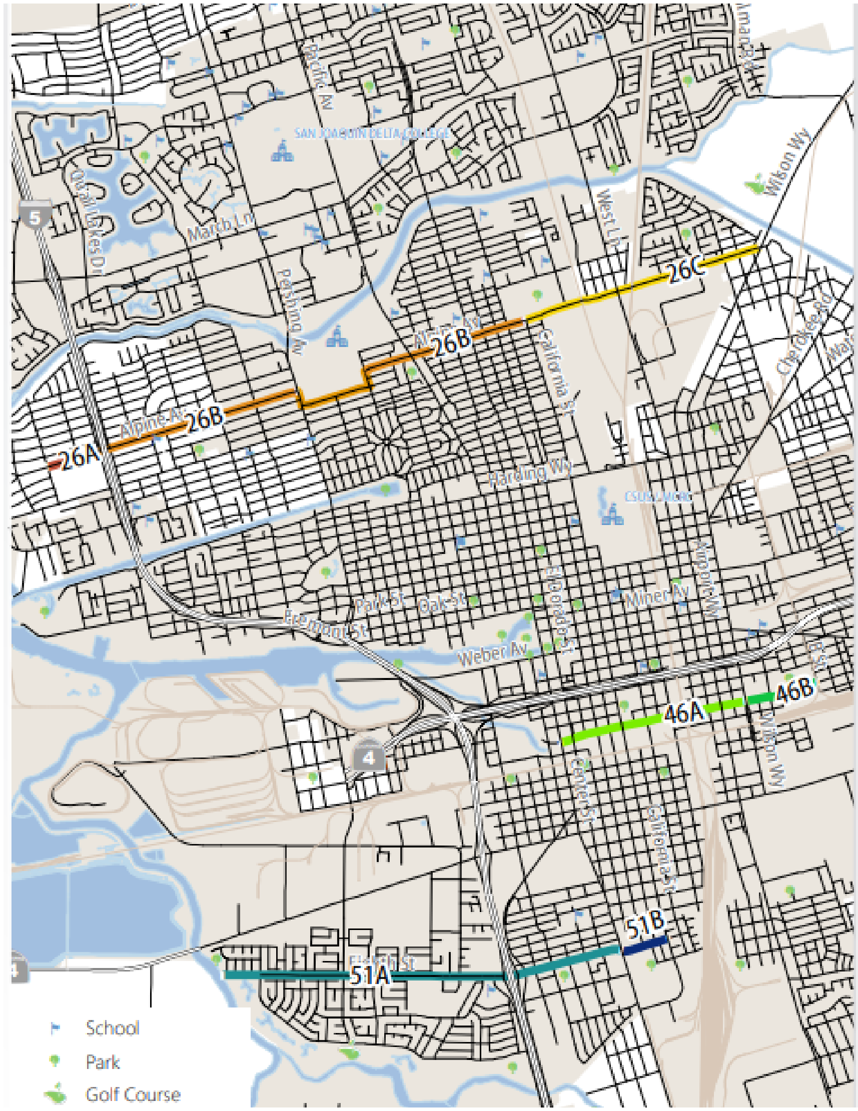
- City of Stockton Bicycle Master Plan
  http://www.stocktongov.com/government/departments/publicworks/projBike.html
- CalEnviroScreen
  https://oehha.ca.gov/calenviroscreen
- Mineta Institute. Low-Stress Bicycling and Network Connectivity
  https://transweb.sjsu.edu/research/low-stress-bicycling-and-network-connectivity
- Northeastern University. Peter Furth LTS Criteria Tables
  http://www.northeastern.edu/peter.furth/research/level-of-traffic-stress/

The Stockton Bicycle Master Plan developed and evaluated alternatives based on several multimodal metrics, including bicycle level of traffic stress. Each alternative clearly outlines impacts for pedestrian, bicycle, transit, and automotive users. The connectivity analysis applies a bicycle level of stress throughout a master plan, providing recommendations for a completed network, improving bicycle connectivity.

The plan also includes a connectivity analysis by neighborhood, estimating the percent change in bicycle connectivity resulting from plan implementation. Neighborhoods identified by CalEnviroScreen as disadvantaged communities were prioritized for improvements in the plan.

Preferred alternatives were recommended for each street studied in the analysis. See Figure 50 as an example. The analysis ensured service quality was considered for all modes.

Figure 49: East/West Access Road Diets in Stockton, CA



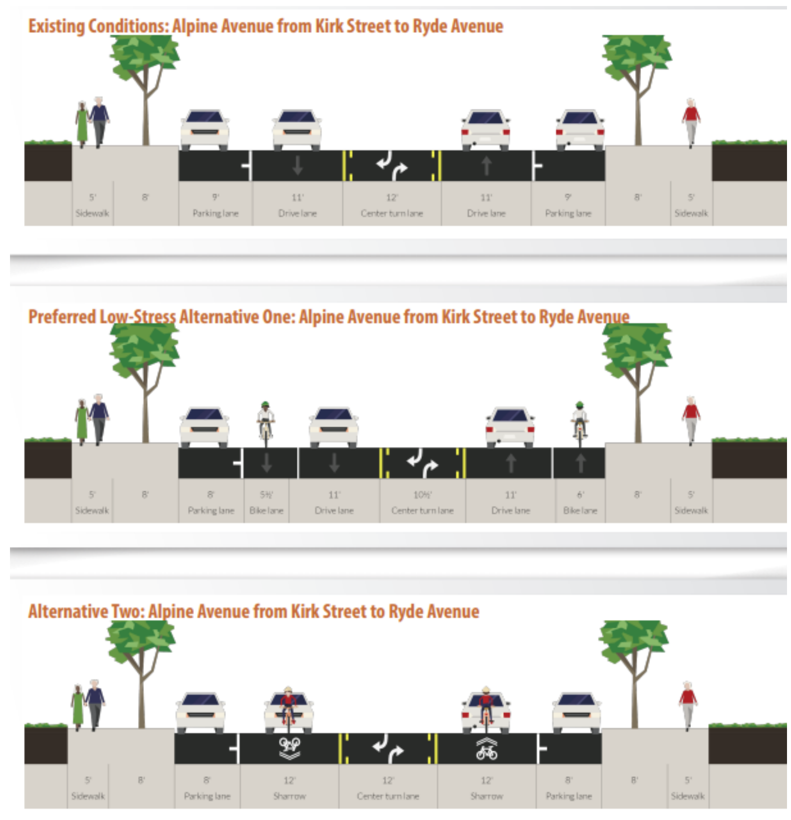
Source: Stockton Bicycle Master Plan

Figure 50: City of Stockton Bicycle Multimodal Metrics Example

Metrics	Ro		
	Segment One: Alpine Avenue from Kirk Street to Ryde Avenue		
	Existing	Preferred Alt	Alt 2
Pedestrian Circulation			
Allows Optimum Sidewalk Width (8 feet plus landscape areas)	Fair	Fair	Fair
Provides Buffer Between Sidewalk and Travel Lane	Good	Good	Good
Minimizes Crossing Distance or Pedestrian Exposure to Autos	Poor	Fair	Poor
Slows Traffic Speeds	Poor	Good	Poor
Bicycle Circulation			
Provides no bike lane; a bike lane; or a cycle track/buffered bike lane	Poor	Fair	Poor
Minimizes conflicts at intersections (turning vehicles)	Poor	Fair	Poor
Minimizes conflicts along block lengths (buses, driveways)	Poor	Fair	Poor
LTS Score	Fair	Good	Fair
Transit Circulation			
Facilitates Provision of Bus Bulbs or Platforms	Fair	Fair	Fair
Expanded Sidewalk Area Facilitates Enhanced Bus Stop Amenities	Fair	Fair	Fair
Resolves of Bus/Bike Conflicts at Bus Stops	Poor	Fair	Poor
Optimize bus stop locations for operations	Fair	Fair	Fair
Accommodates Potential Queue Jump Lanes and Signal Priority	Fair	Fair	Fair
Auto Circulation			
Promotes Slower Traffic Speeds to Increase Safety	Poor	Good	Poor
Number of Lanes Reduces Conflict Points	Fair	Good	Fair
Facilitates Ease/Safety of Parking Maneuvers	Fair	Fair	Fair
Provides network connectivity	Good	Good	Good
Accommodates Traffic Flows Within Reasonable Congestion Limits	Good	Good	Good
Parking Changes			
Change in On-Street Parking Supply Relative to Existing	Fair	Poor	Fair
Composite Score (Maximum of 95 Points Possible)	52	73	52

Source: Stockton Bicycle Master Plan

Figure 51: City of Stockton Existing, Preferred and Alternative 2 for Alpine Avenue



Source: Stockton Bicycle Master Plan

Example: UC Davis Long Range Development Plan

> CASE STUDY AT A GLANCE

STRATEGIES

Evaluate Accessibility

KEY TAKEAWAYS

- Use VMT analysis an indicator of accessibility. Lower VMT can be a proxy for shorter trip lengths or a modal shift.
- Use a local area travel demand model to forecast traffic volumes and impacts of projects on VMT.

RESOURCES

- University of California, Davis. 2018 Long Range Development Plan Final EIR https://environmentalplanning.ucdavis.edu/2018-lrdp-eir/eir
- Caltrans improved data and tools for integrated land use- transportation planning http://ultrans.its.ucdavis.edu/projects/improved-data-and-tools-integrated-land-use-transportation-planning-california

In order to assess the VMT impacts of the *UC Davis Long Range Development Plan*, a transportation analysis for the Environmental Impact Review (EIR) was employed to include analysis of the VMT impacts. A scenario-based approach, modeling for different VMT scenarios was developed. VMT analysis was conducted both for project-related VMT and for the project's effect on the total VMT for the region. The analysis found that locating housing near the center of the campus increased accessibility between students and employees and education and employment destinations. Central campus housing would result in a decrease in 2016 Baseline VMT for the 2016 Baseline plus Orchard Park Redevelopment scenario, shown in the table: 2018 LRDP Effect on Regional VMT- Weekday Conditions. Employees, students, and residents were held constant for scenarios in the same year, providing the same results as a per-capita analysis.

In addition to measuring accessibility, this VMT data was used to measure mobile air pollutant and greenhouse gas (GHG) emissions. With the implementation of Senate Bill (SB) 743, VMT will also be needed for transportation impact analysis. The VMT data related to the project's effect on regional VMT is particularly important for these purposes because it provides a more complete picture of how the project will affect travel long-term. To generate this VMT data, the origin-destination (O-D) method was applied through the SACOG regional model. This method captures all of the VMT associated with any vehicle trip that has a trip starting (origin) or ending (destination) at the UCD campus. Trip data was obtained from the UC Davis Community Travel Survey, the Community Household Travel Survey and the American Community Survey. As such, it is generally considered a full accounting method appropriate for environmental impact analysis in addition to providing insights to accessibility changes. VMT analysis showed that, when housing was located near the center of the campus, VMT directly related to the campus increased, but overall regional VMT decreased because accessibility was improved by providing housing near student and employment destinations.

Figure 52: 2018 LRDP Effect on Regional VMT - Weekday Conditions

Table 3.16-16 2018 LRDP Effect on Regional VMT – Weekday Conditions

VMT Metric	2016 Baseline	2016 Baseline plus West Village Expansion	2016 Baseline plus Orchard Park Redevelopment	2030 No Project	2030 plus 2018 LRDP	2036 (Cumulative) No Project	2036 (Cumulative) plus 2018 LRDP
Total SACOG Region VMT	56,825,300	56,833,500	56,798,600	72,370,400	72,472,200	76,680,900	76,728,400
Difference (From Baseline)	-	+8,200	-26,700	+15,545,100	+15,646,900	+19,855,600	+19,903,100
Difference (From No Project)	-	-	-	-	+ 101,800	-	+ 47,500

Source: 2018 Long Range Development Plan, Final Environmental Impact Report

Example: Virginia SMART SCALE

> CASE STUDY AT A GLANCE

STRATEGIES

Evaluate Accessibility

KEY TAKEAWAYS

- Accessibility measures can be used to prioritize projects for funding.
- The Virginia Department Transportation evaluated projects for the state six year improvement program based on a set of metrics, including access to jobs, access to jobs for disadvantaged persons, and access to multimodal choices.

RESOURCES

- Virginia SMART Scale website
  http://vasmartscale.org/

State DOTs can advance transportation projects which support transportation and land use integration, and accessibility, through statewide prioritization formulas for funding. The commonwealth of Virginia uses a transparent prioritization process, referred to as the SMART SCALE, to fund capacity enhancing projects within its six year improvement program that includes these factors.

Regional and local governments, and transit agencies (with support of regional governments) can submit projects for funding within two categories:

- **High Priority Projects.** These projects must meet a need identified for either a regional network or a corridor of statewide significance.
- **Construction District Grant Programs.** These projects must meet a need identified for a corridor of statewide significance, a regional network, an urban development area, or a safety reason.

SMART SCALE scores proposed projects based on quantifiable measures for six factors: safety, congestion mitigation, accessibility, environmental quality, economic development, and land use and transportation coordination. The accessibility factor considers three measures: 1) access to jobs, 2) access to jobs for disadvantaged persons, and 3) access to multimodal choices. The land use factor awards points for promoting walk/bike friendly development, supporting infill development, and having an access management plan exceeding VDOT standards.

Projects are categorized into four categories: A) corridors of statewide significance; B) regional networks; C) urban development areas; and D) transportation safety needs. The six quantifiable factors carry different weights, depending on the project category. Accessibility measures account for 25 percent of the total score for projects in the regional network and urban development categories. Land use measures are considered for projects in the corridors of statewide significance and regional networks categories.

In 2018, the top scoring projects in the accessibility and land use categories included: transit corridor improvements, transitway expansions, multimodal improvements, and a bridge/tunnel widening project.

This process does not apply to asset management projects, such as bridge and pavement repair, or projects funded through sources with their own criteria, including Congestion Mitigation and Air Quality, Highway Safety Improvement Program, Transportation Alternatives, Revenue Sharing program, and secondary/urban formula funds.[77]

5.EQUITY STRATEGIES

5. Equity Strategies

1. FOSTER EQUITABLE PUBLIC AND STAKEHOLDER ENGAGEMENT
2. ESTABLISH A PROCESS FOR EVALUATING EQUITY RELATED NEEDS AND IMPACTS
3. INVEST IN TRANSPORTATION PROJECTS THAT ADVANCE EQUITY

Why is Equity Important to California Transportation Planners?

Equity in transportation seeks fairness in mobility and accessibility to meet the needs of all community members. Working in partnership with non-transportation agencies, Caltrans can conduct inclusive decisionmaking processes, develop robust plans and policies, and implement projects that improve access to jobs, housing, education, and other everyday activities for all Californians, including low-income adults and children, people living with the effects of systemic discrimination, and individuals with disabilities.

By providing safe, convenient, and affordable access to opportunities for disadvantaged populations, Caltrans can play a key role in helping California's communities to address persistent socio-economic problems that affect, and are affected by, the transportation system.

Lack of Access to Affordable Housing and Living-Wage Jobs

Almost every Californian faces some challenges finding a house or apartment that is in their price range and within a reasonable commute to jobs for which they are qualified. This problem is heightened among disadvantaged populations and makes it harder for them to rise above the obstacles already in their paths. The patchwork of solutions people find to this conundrum can generate intense pressures on transportation systems, as described by the Metropolitan Transportation Commission in Plan Bay Area 2040: *"Rising prices in the region's core have driven many lower-income households to outlying jurisdictions farther away from jobs, transit and amenities... This shift contributes to increased development pressures on open space and agricultural lands, more pollution from passenger vehicles, adverse health impacts, higher transportation costs, and... record levels of freeway congestion and historic crowding on transit systems."*[78]

Disproportionate Risks to Public Health and Safety

Low-income individuals and persons with disabilities face a disproportionately high risk of injuries and fatalities when they travel. In addition, adults and children who live in low-income neighborhoods tend to have higher incidences of chronic diseases such as asthma, diabetes, and heart disease. The reasons for this persistently inequitable exposure to health risks are complex, but are often linked to a lack of safe, complete, and well-connected pedestrian, bicycle, and transit networks in low-income communities. Residents risk their lives daily by walking or biking miles along the shoulders of poorly lit, high-speed highways, or navigating wheelchairs and walkers around crumbling sidewalks, in order to get to work, buy food, and get medical assistance. Children in low-income families suffer the life-altering effects of sedentary lifestyles because they cannot play outside on dangerous streets or walk or bike to parks and recreation centers. Meanwhile, risks of asthma and heart disease among low-income residents of all ages can be heightened by living too close to toxic emissions generated on major highways, rail yards, and ports.

Federal Regulations and Directives

The Civil Rights Act of 1964 lays out the core principles that require Caltrans to strive for an equitable distribution of the benefits and burdens associated with the operation of its infrastructure and services. Subsequent Presidential Executive Orders issued in 1994 and 2000 clarify the types of populations whose needs must be considered in transportation plans and investment decisions: low income persons, members of racial and ethnic minorities, and persons with limited English proficiency.

Title VI:

- Authorizing Directive: Civil Rights Act of 1964 (42 U.S.C. § 2000d et seq.)
- Key Demographics: Race, color, and national origin
- Applicable Agencies/Programs: Programs receiving Federal assistance
- Guidance: 23 CFR Part 200 and 450 and FTA Title VI Circular 4702.1B (2012)

Environmental Justice:

- Authorizing Directive: Executive Order 12898 (1994)
- Key Demographics: Minority persons and low-income persons
- Applicable Agencies/Programs: Federal Agencies and recipients of Federal financial assistance
- Guidance: FTA EJ Circular 4703.1 (2012)

Limited English Proficiency:

- Authorizing Directive: Executive Order 13166 (2000)
- Key Demographics: Individuals with limited ability to read, write, speak, or understand English.
- Applicable Agencies/Programs: Federally funded programs and activities
- Guidance: U.S. Department of Justice Guidance to Federal Financial Assistance Recipients Regarding Title VI Prohibition Against National Origin Discrimination Affecting Limited English Proficient Persons (2000)

Source: California Department of Transportation

Consistent with these requirements, the U.S. DOT has a long-standing commitment to the following principles of environmental justice, and expects State DOTs to adhere to these principles when making plans and investments with Federal funds:

- To avoid, minimize, or mitigate disproportionately high and adverse human health and environmental effects, including social and economic effects, on minority populations and/ low-income populations.
- To ensure the full and fair participation by all potentially affected communities in the transportation decisionmaking process.
- To prevent the denial of, reduction in, or significant delay in the receipt of benefits by minority and/ low-income populations.

California Regulations, Policies, and Directives

In addition to the Smart Mobility Framework Social Equity principles, Caltrans has demonstrated its commitment to equity in several key documents, including:

- Director Policy DP-021 Environmental Justice
- CTP 2040 goal: Foster Livable and Healthy Communities and Promote Social Equity
- Caltrans Strategic Management Plan goal: Sustainability, Livability, and Economy.
- Toward an Active California, Action Item SE2.2: "consider access to economic opportunity as a critical component to serving disadvantaged communities... Incorporate access to employment as a key analysis factor for active transportation improvements and encourage local agencies to do the same for local planning efforts"
- Caltrans Public Participation Plan

STRATEGY AT A GLANCE

5.1 FOSTER EQUITABLE ENGAGEMENT

STRATEGY SUMMARY

- ❑ Develop outreach approaches tailored to disadvantaged communities to encourage participation.
- ❑ Empower underserved communities throughout the life of a project by providing information, listening to feedback, and clearly defining roles of decisionmakers and stakeholders.
- ❑ Build long lasting relationships with representatives of underserved communities.

WHERE IN THE PROCESS TO APPLY

Planning | Project Initiation | Project Development | Operations & Maintenance

RESOURCES

- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)
- FHWA. Developing and Advancing Effective Public Involvement and Environmental Justice Strategies for Rural and Small Communities https://www.fhwa.dot.gov/planning/public_involvement/publications/effective_strategies/index.cfm
- TRB. NCHRP Report 905: Measuring the Effectiveness of Public Involvement in Transportation Planning and Project Development http://www.trb.org/Main/Blurbs/179069.aspx
- Caltrans Planning Public Engagement Contract for on-call public engagement assistance.

5.1 FOSTER EQUITABLE ENGAGEMENT

This section provides an overview of fundamental steps for inclusive and equitable public involvement and stakeholder engagement in the transportation planning processes.

Connect – Develop a tailored outreach approach to encourage participation.

For each project, it is critical to identify and understand the demographics in the region, from the languages spoken, to the places community members live, work, and play. When working with disadvantaged communities, unique, targeted outreach is the most effective practice. Outreach methods that work well in one region may not be as successful in another.

Community outreach starts with awareness and being transparent about the agency's goals. Organizations such as community-based groups, schools or youth groups, faith-based institutions, businesses, and universities can play a critical role in the public involvement process by helping with outreach or serving as stakeholders to provide the perspective of their constituents.

Understanding the needs of community members and how best to connect with them will help planners develop a range of effective outreach strategies such as social media campaigns, traditional mailing lists, bilingual flyers, and radio announcements, as well as engagement techniques, such as focus groups, interviews, and hands-on gaming exercises. Each community may require a different outreach strategy. For example, in communities where smart phones and other technologies are unavailable, social media will not be the strongest strategy.

Educate – Create awareness and empower underserved communities, before, during, and after the life of a project.

When community members feel confident about understanding the transportation decisionmaking process, they may be more inclined to take ownership of the process with the necessary tools and educational resources. This type of ownership leads to sustained participation and the opportunity to gain local leadership experience. Effectively communicating complex issues will equip and empower community members to make meaningful contributions in the public involvement process.

It is important to remember that education is a two-way street when it comes to equitable engagement. Agency representatives must be prepared to hear and convey insights from community representatives about issues and needs the agency may not have considered before. The decisionmaking process must be clearly communicated to all stakeholders. It is also important to manage expectations and to display accountability clearly and consistently.

Sustain – Build long lasting relationships and partnerships.

Public involvement is an ongoing process. Inclusive public involvement aims to continually assess and refine the approach to engaging underserved persons.

Partnering with community organizations or establishing advisory committees can help build trust between the agency and the communities. An advisory committee, which consists of stakeholders, agency representatives, and leaders of local groups, can provide an opportunity for underserved persons and agency representatives to collaborate.

Attending meetings and events hosted by established community groups, such as nonprofits, and other local institutions can be a good way to connect with community members, as opposed to setting up a separate public meeting. Community members may have limited ability to travel or difficulty making meetings and it may be easier to reach people at events with established participation.

Barriers such as transportation access, childcare needs, or cultural or linguistic challenges can prevent people from attending meetings or providing input and should be addressed when soliciting input from underserved communities. Online surveys or interactive websites can be a good way to solicit input from community members. Access to information about events, upcoming projects, and meetings should always be available to the public. For example, a website or an automated phoneline would offer access to information at all times.

Caltrans has several programs and initiatives to work with stakeholders and representatives of underserved communities. Planners can build on these relationships. For example, Caltrans sponsors work groups such as the Native American Advisory Committee (NAAC), Active Transportation and Livable Communities (ATLC), and the California Bicycle Advisory Committee (CBAC). Many of these groups have websites, email lists, and meetings that provide opportunities to give input on projects.

Caltrans has a Planning Public Engagement Contract that retains public engagement specialists to work with Districts on plans and project development. These specialists have experience with multiple methods of engagement, including online interactive mapping for public comments and data collection. District planners may apply for on-call assistance through the Caltrans Office of Planning.

STRATEGY AT A GLANCE

5.2 ESTABLISH A PROCESS FOR EVALUATING EQUITY

STRATEGY SUMMARY

- ❑ Identify populations for analyses, using disadvantaged communities defined by Federal and state guidance.
- ❑ Identify needs and concerns through data analysis and stakeholder outreach.
- ❑ Measure impacts of proposed activities (such as road designs or investments) on disadvantaged communities in relation to the remainder of the population.
- ❑ Analyze impacts to disadvantaged communities to determine if impacts are disparate or disproportionately high.
- ❑ Develop strategies to mitigate inequities.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- CalEnviroScreen
  https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30
- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)
- FHWA. Environmental Justice Reference Guide
  https://www.fhwa.dot.gov/environment/environmental_justice/publications/reference_guide_2015/fhwahep15035..pdf

5.2 ESTABLISH A PROCESS FOR EVALUATING EQUITY

Establishing a consistent process for evaluating equity in transportation plans and projects will integrate the concept of equity into all plans and projects and address any possible inequities early in the planning process. The following five-step framework is applicable to many types of planning and decisionmaking processes, including corridor plans.

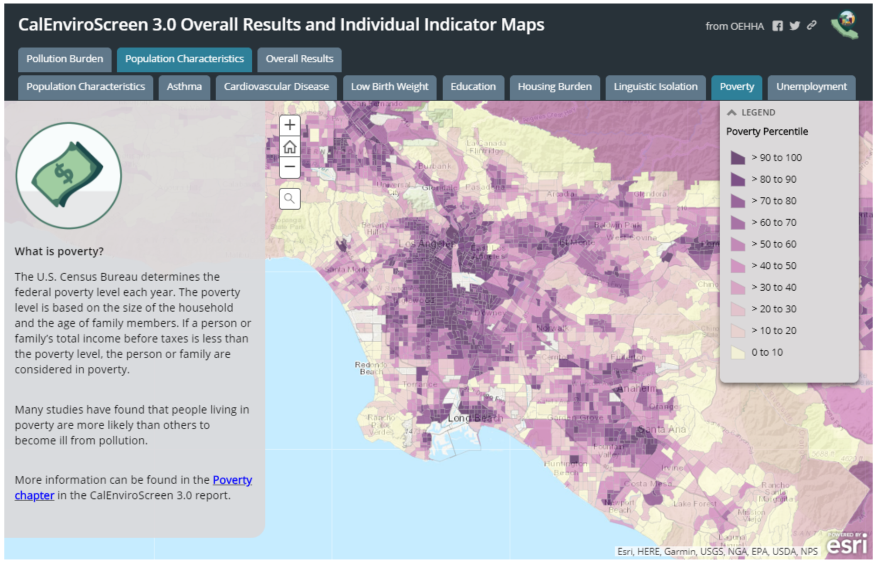
1. **Identify populations for analysis.** Use demographic data and stakeholder input to identify the locations and characteristics of disadvantaged populations
2. **Identify needs and concerns.** Conduct outreach and collect data to understand the needs of underserved persons.
3. **Measure impacts of proposed agency activity.** Assess plans and projects to determine whether benefits and burdens are equitably distributed between underserved persons and the population in general.
4. **Determine whether differences are disparate or have disproportionately high and adverse effects (DHAE).** Agencies responsible for federally-funded programs and activities are required to assess and address potential disparate impacts. Generally, a disparate impact is defined as one where a policy or practice disproportionately affects members of a disadvantaged group without a legitimate justification and/or when there are alternatives with less disproportionate impact. A disproportionately high adverse effect includes individual and cumulative impacts as well as the denial of, reduction in, or significant delay in the receipt of, benefits.
5. **Develop strategies to mitigate inequities.** If the impact analysis reveals that a plan or project has a disproportionate and highly adverse effect (DHAE) on underserved persons, examine alternatives that mitigate these impacts. Mitigation strategies should directly address identified disparate impacts/ DHAE related to the needs and concerns identified in Step 2 as well as the impacts of proposed plans determined in Step 3.

Step 1: Identify Populations for Analysis

The first step is to determine what disadvantaged or vulnerable population groups are located in the project area.

- **Define population groups for analysis.** Identify all populations for consideration within or adjacent to/impacted by the planning project. The EJ Executive Order lists specific minority populations that agencies should consider in order to comply with Title VI, and adds low-income individuals to the list of required populations. The LEP Executive Order adds persons with limited ability to read, write, and understand English. Transportation agencies must consider the needs of these populations in order to comply with Federal directives, and many California agencies and communities tailor their analyses to consider additional groups of importance, such as persons with disabilities, older adults, and children. Most data can be found from the U.S. Census American Community Survey or local sources. CalEnviroScreen is an online mapping tool with compiled data on disadvantaged communities and a scoring system for census tracts that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. This tool also identifies "priority populations" which are specifically targeted for investments from the California Climate Investments program.[79] [80]
- **Identify high-priority areas.** High priority areas can be areas with high concentrations of underserved persons, areas of importance to underserved persons (such as a community, medical, or religious center), or other areas identified through analysis and public outreach. Some Federal certification programs require an agency to identify areas with high concentrations of underserved persons.
- **Identify distribution of underserved persons.** In addition to identifying geographic areas with significant concentrations of disadvantaged or underserved persons, an analysis of the overall distribution of these persons throughout the project area (and areas impacted by the project) can reveal insights that could be missed if an agency focuses solely on areas with high concentrations of underserved persons. This analysis allows agencies to consider the members of underserved populations even when they do not live in underserved communities.
- **Understand demographic change.** An area's demographic makeup is always changing. Many urban areas are grappling with gentrification caused by neighborhood redevelopment and housing price trends. Meanwhile, numerous regions throughout the country have undergone rapid rises or falls in numbers of different demographic groups and/or economic conditions. It is difficult to accurately forecast future population composition and distribution based on jagged historic trend lines. In rapidly evolving communities, planners should consider the changing makeup of the community rather than simply rely on present-day statistics.

Figure 53: Sample Percent Poverty Map from CalEnviroScreen



Source: CalEnviroScreen

Step 2: Identify Needs and Concerns

After determining population groups to consider, the next step is to identify the needs and concerns of those groups. Start with a regional analysis, then target neighborhood level engagement.

Depending on the size and scale of a project, start with a regional analysis of underserved persons, then focus analysis on specific, high-priority neighborhoods for a better understanding of specific needs in those areas. Conduct on-the-ground audits, if necessary. Needs should be identified through both data analysis and stakeholder input.

- Gather input from underserved persons about the appropriate issues to analyze;
- Assess exposure to the burdens of the transportation system, such as environmental health and safety conditions;
- Assess access to the benefits of the transportation system, especially access to jobs and services via transit; and
- Validate findings with stakeholder input.

Source: Fitzgerald Halliday, Inc.

Step 3: Measure Impacts of Proposed Agency Activity

The next step is to measure the proposed activity's impact (typically a road design or element) on underserved communities or populations. Impacts may be informed by the needs and concerns analyses performed in Step 2.

- **Select indicators:** The first step to assessing impacts is to select indicators to measure the impacts, benefits, and burdens of the agency's actions. Indicators can describe outputs (direct products of an agency's actions) or outcomes (an achievement that has occurred because of the actions taken by an agency). Table 5 lists some commonly used indicators.

Table 5: Sample Indicators

Benefit or Burden	Output Indicator	Outcome Indicator
Travel/commute time	Dollars invested in projects/ project elements to improve system efficiency	Average commute travel times (for all modes)
Access to transit	Frequency or coverage of transit routes	Number of households with access to transit
Walkability	Pedestrian network connectivity index	Change in travel times to key destinations by mode

- **Measure impacts:** A typical approach to measure outputs (impacts attributable to an agency's action) is to compare the distribution of funding between projects that will benefit underserved communities and the remainder of the project area or impacted area. A typical approach to measure outcomes (impacts that occur due to an agency's action) is to use a travel model to forecast the impacts of an investment or project on the system performance and analyze impacts to traffic analysis zones (TAZs). TAZs can be categorized by the percentage of underserved populations within them and compared for impacts.

Step 4: Determine Disparity/DHAE

After measuring impacts, the next step is to determine if those impacts are disparate or have disproportionately high adverse effects (DHAE). Based on the data collected and analyzed in Steps 2 and 3, summarize differences experienced by different population groups from agency outputs (e.g., agency investments) and existing and forecasted outcomes relating to accessibility, safety, environmental quality, and health risk.

- **Screen for DHAE impacts using quantitative methods.** Quantitative methods (such as benchmarking, statistical significance, and location quotients) are helpful for screening for potential disparate impacts to identify impacts that may warrant additional investigation.
- **Validate findings with qualitative methods and stakeholder involvement.** After conducting a quantitative method to screen for disparate impacts, a qualitative analysis, such as surveys or stakeholder interviews, can validate or clarify issues. Qualitative methods inform analysis of disparate impacts with the values, attitudes, knowledge, and preferences of underserved persons. Qualitative methods should determine which impacts are considered as benefits or burdens, and how significantly they are felt within the community.
- **Diagnose why disparities and impacts exist.** If disparate impacts or DHAE are identified in plans or programs, the next steps are to diagnose the factors contributing to the existing or forecasted disparity/ DHAE, and to ensure that future actions mitigate and remedy those impacts or effects.

Quantitative Methods for Screening

- **Establish benchmarks to flag differences.** Establish benchmarks for the percentage of differences in indicator values between population groups to flag potentially disparate impacts for further investigation. Justify benchmark values with relevant contextual and historical information for each indicator. Comparison to existing conditions could be useful in establishing benchmarks.
- **Use statistical significance to screen for disparity.** Guidance from the U.S. EPA on EJ impacts recommends using statistical significance, which is a statistical method for confirming that an identified variation is not occurring by chance.
- **Understand limitations of quantitative analysis.** Both of the quantitative analyses described previously are limited in their ability to determine disparate impacts. The values used for benchmarks are subjective choices set by stakeholders or determined by policies; communities that experience small impacts relative to the benchmark could still be experiencing disproportionate impacts.

Step 5: Develop Strategies to Avoid/ Mitigate Impacts

Once impacts are identified, steps to avoid or mitigate these impacts should be taken. Mitigation measures are dependent on the particular issues, however, some typical actions include the following:

- **Revise project evaluation criteria.** Use project prioritization methods to support investments in underserved communities and that address the needs identified by underserved persons.
- **Fund activities that remedy disparate impacts/DHAE.** Consider projects to mitigate existing impacts or make improvements to benefit underserved populations. These can be proactive steps, rather than responding to identified inequities in proposed projects.
- **Improve underserved persons' engagement in planning processes.** Include underserved persons throughout the transportation planning decisionmaking process. Underserved persons should have representation on advisory boards, stakeholder groups, or other committees, with clearly defined roles.
- **Evaluate and measure progress.** Establish equity performance measures to track over time. These measures can be shared with the public using online dashboards for transparency and accountability.

Source: MIG Inc.

STRATEGY AT A GLANCE

5.3 MAKE INVESTMENTS THAT ADVANCE EQUITY

STRATEGY SUMMARY

- ❑ Invest in projects that increase access to social and economic opportunities for disadvantaged communities.
- ❑ Provide high quality and affordable public transit.
- ❑ Invest in active transportation facilities.

WHERE IN THE PROCESS TO APPLY

RESOURCES

- California Climate Change Investments Program https://calepa.ca.gov/EnvJustice/GHGInvest/
- CalEnviroScreen https://oehha.ca.gov/calenviroscreen
- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)

5.3 MAKE INVESTMENTS THAT ADVANCE EQUITY

Low-income and minority communities are less likely to have convenient access to employment opportunities, healthcare, or parks. Minority and low-income households typically own fewer vehicles, have longer commutes, and have higher transportation costs. Inadequate or substandard infrastructure in low-income and minority communities can prevent people from accessing the services they need the most.

Transportation planning decisions can affect employment and economic development which have distributional impacts. Investing in transportation programs and services that are affordable, accessible, and reliable can reduce the negative impacts to underserved communities. The following types of investments can advance equity in underserved communities:

- **Expand connections between services and underserved communities.** Underserved persons may be physically isolated from job opportunities and services. Propose or prioritize projects that increase access to social and economic opportunities, such as jobs, affordable housing, healthy food, education, health care, and recreation.
- **Provide quality and affordable public transit facilities and services.** Transit-dependent communities need reliable and safe commuting options. Work with local transit agencies to improve transit routes and schedules to reflect the travel patterns and needs of people using transit for daily travel, including low-wage workers, individuals and families without vehicles, persons with disabilities, people traveling to and from jobs at non-traditional times, children, and older adults who are unable to drive.
- **Support active transportation options.** Invest in projects that support active transportation and provide safe, smart, and affordable transportation alternatives that minimize automobile dependency to create healthier, more sustainable communities.

- **Integrate equity as a standard practice at the agency and program level.** Develop a workforce program to increase access to jobs and training in the transportation industry for communities that are historically underrepresented. Recruit, retain, and support a diverse staff at every level to ensure that decisionmakers represent the communities they serve, particularly in race and ethnicity. Create staff education opportunities in community engagement, cultural competency, diversity, and sensitivity trainings.

California Climate Investments Program

Funding is available from the Climate Change Investments Program for projects designed to improve "public health, quality of life and economic opportunity in California's most burdened communities at the same time they're reducing pollution that causes climate change." Priority populations, as defined in CalEnviroScreen are specficially targeted for projects funded under this program.

The Climate Change Investments Program is funded by proceeds from California's Cap and Trade Program.

EQUITY PERFORMANCE MEASURES, ANALYSIS METHODS, AND RESOURCES

SCALE	PERFORMANCE MEASURES	METHODS AND RESOURCES
SINGLE PROJECT	• Benefits and burdens associated with the project (such as pollution, displacement, property value, improved or reduced access) in disadvantaged populations compared to non disadvantaged populations • Members of minority, low-income, or other disadvantaged population participation on advisory board, stakeholder group, or other participatory outlet	• Model enhancements to recognize potential displacement related to transportation investment • SafeTREC (Data analysis, tools, research and resources related to transportation safety from the University of California, Berkeley) • CalEnviroScreen
LOCAL NETWORK OR LARGE AREA SYSTEM	• Travel times by mode, access to transit, access to jobs or key destinationsin disadvantaged populations compared to non disadvantaged populations • Crash rates or other safety metrics in disadvantaged populations compared to non disadvantaged populations • Members of minority, low-income, or other disadvantaged population participation on advisory board, stakeholder group, or other participatory outlet	• SafeTREC • CalEnviroScreen • Household and business inventories, and travel surveys • Transit service inventories and service plans • Special generator surveys of day care, senior centers, medical facilities, ADA access surveys

RESOURCES: EQUITY

- U.S. DOT Environmental Justice Order 5610.2(a)
  https://www.transportation.gov/transportation-policy/environmental-justice/department-transportation-order-56102a
- U.S. DOT Environmental Justice Strategy
  https://www.transportation.gov/transportation-policy/environmental-justice/environmental-justice-strategy
- FHWA Order 6640.23A: Actions to Address on Environmental Justice in Minority Populations and Low-Income Populations
  https://www.fhwa.dot.gov/legsregs/directives/orders/664023a.cfm
- FHWA Guidance on Environmental Justice and NEPA Memorandum
  https://www.environment.fhwa.dot.gov/env_topics/ej/guidance_ejustice-nepa.aspx
- Caltrans Corridor Planning Process Guide
  https://dot.ca.gov/programs/transportation-planning/multi-modal-system-planning/guidelines-procedures/corridor-planning-process-guide
- California Climate Change Investments Program
  https://calepa.ca.gov/EnvJustice/GHGInvest
- Government Alliance on Race and Equity Capitol Cohort
  http://sgc.ca.gov/programs/hiap/racial-equity/
- CalEnviroScreen
  https://oehha.ca.gov/calenviroscreen
- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)
- SafeTREC
  https://safetrec.berkeley.edu

Example: MARC Targeting Safety in Underserved Communities

> CASE STUDY AT A GLANCE

STRATEGIES

Make Investments that Advance Equity; Foster Equitable Engagement

KEY TAKEAWAYS

- Analyze safety metrics between disadvantaged and non-disadvantaged communities to determine disparity.
- Prioritize funding on mitigating safety issues in disadvantaged communities.
- Establish performance measures for equitable investment.

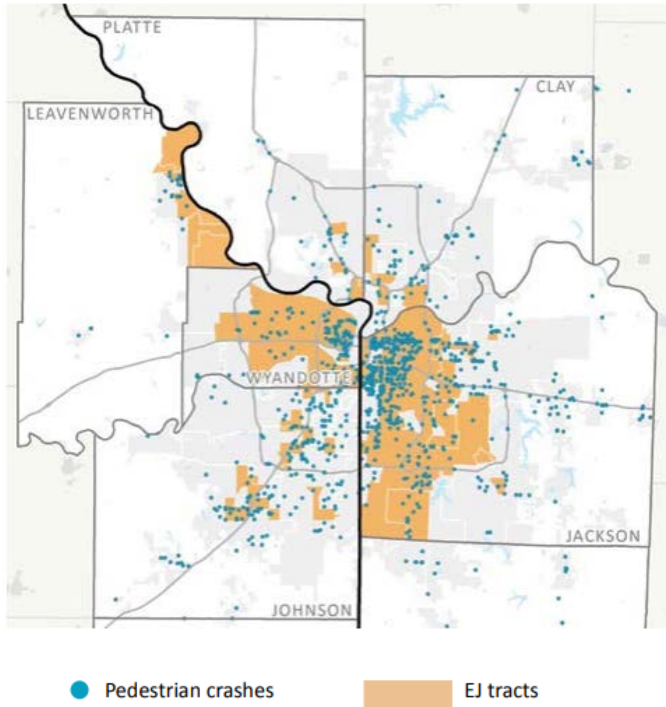
RESOURCES

- Mid-America Regional Council Transportation Outlook 2040 http://www.to2040.org/
- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)

The Mid-America Regional Council (MARC), the metropolitan planning organization for the Kansas City metropolitan area, conducted an equity analysis as part of its 2040 Long Range Transportation Plan. As part of this analysis, MARC mapped crash data and disadvantaged communities and found that most of the bicycle and pedestrian crashes that resulted in fatalities were located in disadvantaged communities. Further analysis revealed that safety funding was primarily distributed to communities outside of Environmental Justice tracts. To address this issue, MARC identified high-severity crash locations in Environmental Justice areas which were then compared to proposed projects for their Transportation Improvement Program (TIP). Proposed projects that addressed safety issues in these high-severity crash locations were prioritized for funding in order to ensure that transportation investments were being distributed in an equitable manner.

The Long Range Transportation Plan includes a performance measures for transportation investment in Environmental Justice areas. The percent of Federal funds for projects located in Environmental Justice areas increased from 49 percent in the 2012–2016 TIP to 69 percent in the 2014 to 2018 TIP.

Figure 54: Pedestrian Crashes and Underserved Communities



Source: Mid-America Regional Council. Transportation Outlook 2040

Example: MTC Equity Assessment for Project Performance Assessment

> CASE STUDY AT A GLANCE

STRATEGIES

Establish a Process for Evaluating Equity

KEY TAKEAWAYS

- Use multiple methods for evaluating equity
- Identify populations appropriate for the project context

RESOURCES

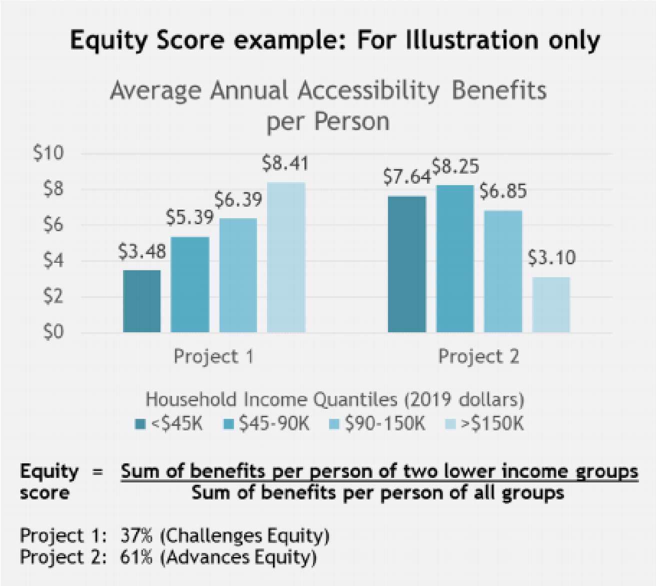
- Horizon/Plan Bay Area 2050: Revised Project Performance Assessment Methodology https://mtc.ca.gov/sites/default/files/ProjectPerformance_Methodology.pdf
- Transportation Research Cooperative Program. Guide To Equity Analysis In Regional Transportation Planning Processes (2020)

The Metropolitan Transportation Commission (MTC), the metropolitan planning organization for the Bay Area in California, includes equity analyses as part of their project performance assessments for their 2050 Long Range Transportation Plan. All transportation projects considered for inclusion in the plan were evaluated individually for their impacts on the region. The agency scored the projects based on the results of a benefit-cost assessment, equity assessment, and guiding principles assessment, under three future scenarios.

The equity assessment is based on two factors, a geographic assessment and an assessment of accessibility benefits among income groups.

The Geographic Assessment identifies whether a project provides access directly to a Community of Concern. Communities of Concern are defined as census tracts that meet thresholds for disadvantaged populations: Minority (70%); Low Income (30%), Low English Proficiency (20%); Elderly (10%); Zero Vehicle Household (10%), Single Parent Household (20%); Disabled (25%); Rent-burdened Household (15%). A tract is considered a COC if it exceeds the threshold for both Low Income and Minority, or Low Income, plus three other variables.

Figure 55: Illustration of Equity Score



Source: MTC Plan Bay Area 2050

The Accessibility Benefits across Income Groups Assessment examines the distributive impacts of accessibility benefits across income groups, using the MPO's travel mode outputs. Projects are run through the travel model for each of the future scenarios where the model identifies accessibility for each income group. Accessibility benefits are derived from a benefit cost analysis conducted for each project. MTC's Travel Model 1.5 outputs of Changes in Accessibility Benefits are split into four income groups at the TAZ subzone levels. The Accessibility Benefits score is calculated as the ratio of benefits per capita of the two lower income groups to the sum of benefits per capita of all income groups. Higher scores indicate more accessibility benefits to those in the two lower groups. Projects are considered to "Advance Equity" if the ratio is over 60% benefits to low income persons, "Challenge Equity" if the ratio is less than 40% of benefits to low income persons, or "Even Distribution", where the ratio falls within 40-60%.

6.USING PLACE TYPES TO ADVANCE SMART MOBILITY

About Place Types

Place types describe geographic areas based on land use, the transportation system, and other characteristics. Place types can help transportation agencies determine the investments and system management approaches that are most appropriate for a given location. The use of place-based approaches to planning and design has been growing in recent years. Stemming from an early basis in urban design and zoning, place types are now being used to help formulate strategies for other applications, including transit-oriented development, context sensitive design, and modal priorities for the transportation network. For Caltrans, the use of place types to inform transportation planning and project development was first introduced in *Smart Mobility 2010*.

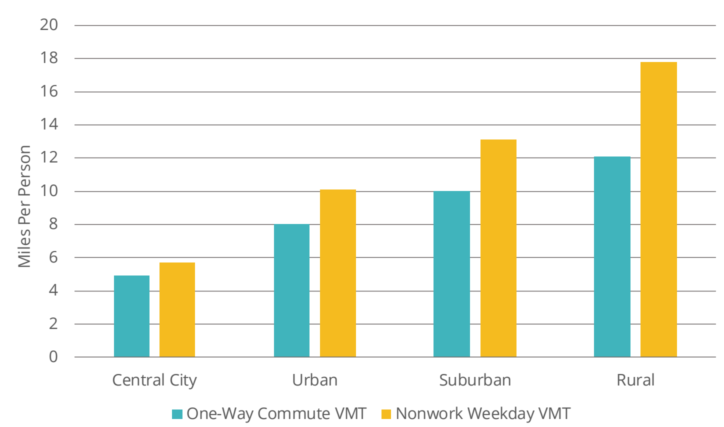
There are numerous systems of place types, often developed for zoning and urban design purposes. One well-known system is the rural-to-urban Transect, which consists of the following six Transect Zones: Core (T6), Center (T5), General Urban (T4), Sub-Urban (T3), Rural (T2), and Natural (T1). Many of California's MPOs have developed and applied systems of place types as part of the regional planning process. For example, the 2020 Regional Transportation Plan developed by the Southern California Association of Governments (SCAG) involved use of a Scenario Planning Model that includes 32 place types. The 2020 Metropolitan Transportation Plan developed by the Sacramento Area Council of Governments (SACOG) involved land use scenarios using six community types. These systems can include more than 20 individual place types. For applying the Smart Mobility Framework, this guide uses a simpler system consisting of the following five place types:

- Central Cities
- Urban Communities
- Suburban Communities
- Rural Areas
- Protected Lands and Special Use Areas

This section describes each of the five place types and associated appropriate transportation planning priorities. Each set of recommendations serves as a guide, not a rule. Every location has its own unique context and planners should consider the specific characteristics of a given planning area when identifying transportation improvements. Table 6 lists descriptions, examples, and metrics for mapping for the place types used in this guide.

The land use and transportation system characteristics of place types strongly influence travel behavior. Locations with higher density, mixed-use development patterns coupled with well-connected multimodal transportation systems encourage shorter trips and travel by non-automobile modes, both of which tend to reduce VMT. Research by Dr. Deborah Salon of UC Davis compiled recent travel surveys from the large MPOs in California to analyze travel by place type across the state.[81] Figure 56 shows average daily commute and non-work VMT by place type, based on this research, illustrating the dramatic differences in VMT. For example, individuals living in Suburban Communities drive more than twice as much as Central City residents for non-work trips.

Figure 56: VMT by Place Type



Source: Salon, Deborah, 2015. "Heterogeneity in the relationship between the built environment and driving: Focus on neighborhood type and travel purpose." Research in Transportation Economics. 52: 34-45

Table 6: Place Type Characteristics

Type	Description	Metrics	Examples
Central Cities	High density, mixed-use places with well-connected grid street networks, high levels of transit service, and pedestrian supportive environments.	• Avg pop density: 40,000* • Avg transit mode share: 33% • Avg road density: 28**	Downtowns of San Francisco, Oakland, San Jose, Sacramento, Los Angeles, San Diego
Urban Communities	Moderately dense places, mostly residential but with mixed-use centers. Housing is varied in density and type. Transit is available to connect neighborhoods to multiple destinations. Fine-grained network of streets with good connectivity for pedestrians and bicyclists.	• Avg pop density: 15,500 • Avg transit mode share: 10% • Avg road density: 26	Berkeley, Midtown and Curtis Park Sacramento, East and West Los Angeles, Santa Monica, Hillcrest and Little Italy San Diego
Suburban Communities	Primarily lower density residential with a high proportion of detached housing. Some interspersed retail and services, but little mixing of housing with commercial uses. Street networks often have poor connectivity. Low levels of transit service, large amounts of surface parking, and inconsistent pedestrian networks.	• Avg pop density: 6,800 • Avg transit mode share: 3% • Avg road density: 19	Fremont, Milpitas, Pleasanton, Citrus Heights Sacramento, Roseville, Elk Grove, typical areas of Orange County and Inland Empire counties, Central Valley and Salinas Valley suburbs
Rural Areas	Very low density places with widely-spaced towns separated by farms, vineyards, orchards, or grazing lands. Includes rural towns that provide a mix of housing, services, and public institutions in compact form that serve surrounding rural areas. May include tourist and recreation destinations which can significantly affect land uses, character, and mobility needs. Very limited modal choices.	• Avg pop density: 340 • Avg transit mode share: 1% • Avg road density: 3.5	Hilmar, Ferndale, Los Molinos, Gridley, Sutter Creek; much of the northern coast, Central Valley, and Sierra foothills outside metropolitan areas
Protected Lands and Special Use Areas	Lands protected from development by virtue of ownership, long-term regulation, or resource constraints. Also includes large tracts of single use lands that are outside of, or poorly integrated with, their surroundings.	• N/A	Protected lands include national forests and lands held in perpetuity by land trusts. Special use areas include airports, industrial facilities, military installations, some universities.

**Population density is defined as persons per square mile*

*** Road density is defined as roadway miles per square mile*

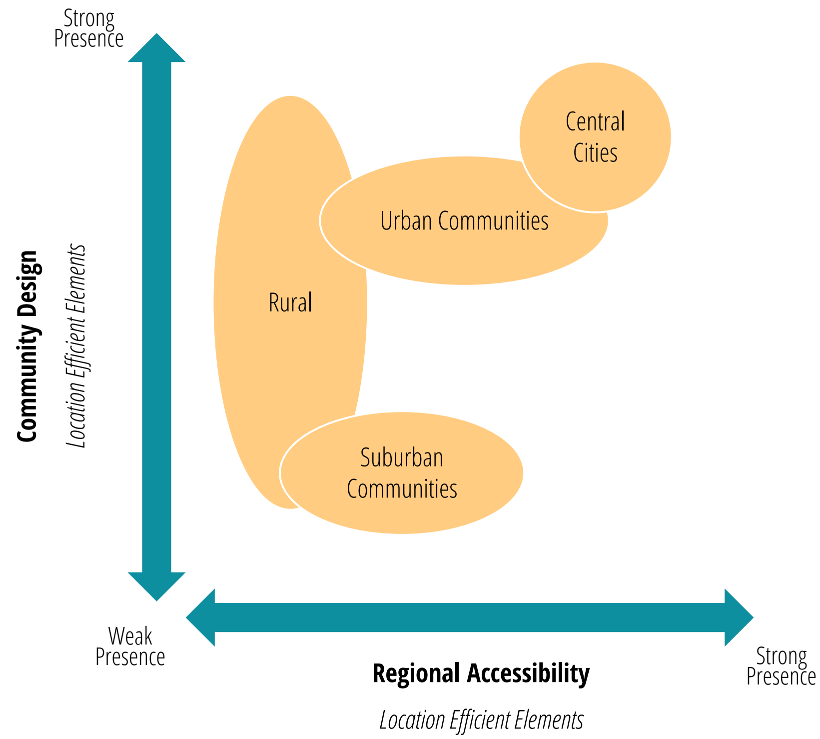
Place Types and Location Efficiency

As described previously in this guide, location efficiency is the fit between the physical environment and the transportation system, which can lead to smart mobility benefits. An area's location efficiency is determined by two components: regional accessibility (combination of development pattern, geographic location, and transportation system) and community design elements (development pattern and transportation system at the neighborhood scale). A place with strong regional accessibility is one with proximity to major regional destinations, benefiting from robust transportation network and high level of multimodal access for all users to major institutions and neighborhoods throughout the region. Community design elements, the other dimension of location efficiency, pertain to the local character of land use, urban design, and the transportation network. Strong community design occurs in places where development use, form, and location combine with a multimodal transportation system that supports convenience, non-motorized travel, and efficient vehicle trips at the neighborhood and area scale.

- **Central Cities** always have both strong regional accessibility and strong community design, so these places exhibit the greatest smart mobility benefits.
- **Urban Communities** consistently have strong community design but can vary in terms of regional accessibility. Urban Communities that border Central Cities have strong regional accessibility. Conversely, some Urban Communities are located in more remote areas of the state and have weak regional accessibility despite strong community design elements; examples include the central areas of Eureka, San Luis Obispo, and Paso Robles.
- **Suburban Communities** generally have moderate to weak community design elements and can vary in terms of regional accessibility. Similar to Urban Communities, Suburban Communities that border Central Cities have strong regional accessibility, but those located in more remote areas of the state have weak regional accessibility.
- **Rural Areas** lack strong regional accessibility and can vary in terms of community design. While they typically lack public transit service, many historic rural towns have mixed land uses with a fine-grained circulation network of streets with high comfort for pedestrians and bicyclists. Other rural communities have larger lots and a roadway network that discourages non-motorized travel, and therefore exhibit community design elements.

Figure 57 illustrates the relationship between the local efficiency factors and the place types described in this guide.

Figure 57: Place Types and Location Efficiency



Identifying and Mapping Place Types

Smart Mobility 2010 does not contain any numeric definitions that would enable mapping of the place types to specific locations in the state. This guide uses a slightly different set of place types, based on research conducted by Dr. Deborah Salon of UC Davis. This research defines five place types at the census tract level, using characteristics such as population density, transportation mode share, road density, job access, and other parameters. The place types defined in this guide use the quantitative characteristics of Dr. Salon's place types to enable planners to apply GIS analysis to determine which place type applies to a specific location in the state.

As a caveat, place types are necessarily broad. Detailed mapping would show that types often co-exist in larger areas. The place types are intended to be applied at a generalized level of detail, with the understanding that detailed planning for specific places will provide greater differentiation of locations. In fact, within any large area designated as one of the place types, there will typically be subareas with the character of other places. There are, for example, protected open space lands even within high-rise urban centers. The state's size and complexity makes this variation inevitable.

Table 6 lists metrics for analyzing place types. Data analysis for place types can be conducted for cities, census tracts, or block groups within the planning area and compared to Table 6 to determine the specific place type that applies. There may be a need for professional judgment of place type if the metrics do not match a single place type category. Descriptive characteristics in this chapter can help planners determine the best fit for their planning area.

Three metrics can be used to determine place type are population density, transit mode share, and road density. Many other socioeconomic, transportation, and land use metrics can be reported for place types and can be used to inform planning and project priorities. Population density and transit mode share numbers can be obtained from the US Census. The American Community Survey 5 Year Data includes total population and transit mode share at the city, census tract and block group levels. Population density is calculated by dividing total population by the study area.

Road density is calculated in a GIS mapping application as the ratio of total length of all roads to the land area within the tract or block group. Using a GIS mapping application, intersect TIGER line files shapefiles (All Roads layer, available from the US Census or commercial sources) with the city, census tract or block group boundary, calculate the linear miles of all roads in the study area, and divide this number by the square miles of the study area.

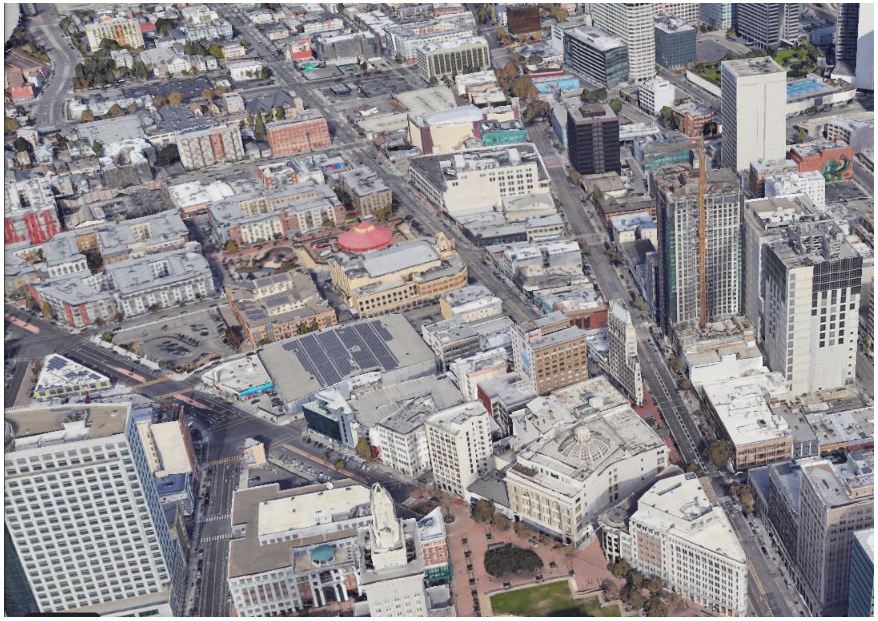
Guidance for Place Types

Place types are a tool to classify neighborhoods, towns, cities, and larger areas for purposes of making investment, planning, and management decisions that advance smart mobility. Specifically, place types are useful for:

- Identifying appropriate integrated transportation and land use planning activities that can become part of ongoing local and regional planning activities with extensive community engagement, such as general plan updates and preparation of sustainable communities strategies.
- Identifying types of transportation projects and programs that should be considered as possible priorities in order to increase the presence of location efficiency factors and yield smart mobility benefits.
- Identifying types of land use, community development, and conservation activities that should be considered as possible priorities in order to increase the presence of location efficiency factors and yield smart mobility benefits.
- Identifying activities, resources, and techniques that will support planning, investment, and program decisionmaking.
- Bringing attention to opportunities for investments and programs to influence change in places so they achieve higher levels of location efficiency and therefore greater potential to gain smart mobility's benefits.

These activities may be undertaken by Caltrans, partner agencies at all levels of government, and non-governmental organizations. Guidance for activities appropriate to the Smart Mobility Framework for each of the place types is presented in this section within each place type description.

Central Cities



Description: Central Cities are the central business districts of large metropolitan areas. Buildings rise higher than four stories and typically include large office and workplace components. Building setbacks are typically zero to 10 feet. These places have a rectilinear grid street pattern with parking in structures. The average population density is about 15,000 persons per square kilometer, with high road density and typically a high transit mode share.

Central Cities facilitate the most modal options and lowest single occupancy vehicle (SOV) use per capita. They are characterized by having high intersection density, high bicycle, pedestrian, and transit mode shares, and lower vehicle speeds. Increasingly, these place types support new and emerging forms of mobility including TNCs and micromobility modes, such as electric bicycles and scooters. Automobile ownership is typically lower than other areas and parking is often limited and requires payment.

Central Cities serve as major transportation hubs and offer interregional connections through intercity bus, rail, airports, and in some areas, ferries. Investments in expanded roadway capacity should be very limited, with major investments instead focused on transit capacity and system management.

Reliability is a key objective guiding investment and operations in Central Cities. One dimension is providing people with the ability to conveniently use walk, bike, and high-capacity transit modes on dedicated right of way. Another is an approach to street and intersection operations that focuses on providing predictable travel times with traffic and incident management rather than seeking to relieve recurrent congestion in these high-activity areas. A high level of network connectivity increases reliability by connecting origin/destination pairs with multiple routes, making trips more direct, and supporting multiple ways to travel.

Challenges: Traffic congestion, travel time reliability, livability due to high costs of living, modal conflicts, and maintaining high-quality and high-coverage transit systems are common challenges in Central Cities. High-quality transit systems to reduce congestion and improve mobility in these place types can be expensive for transit providers and users.

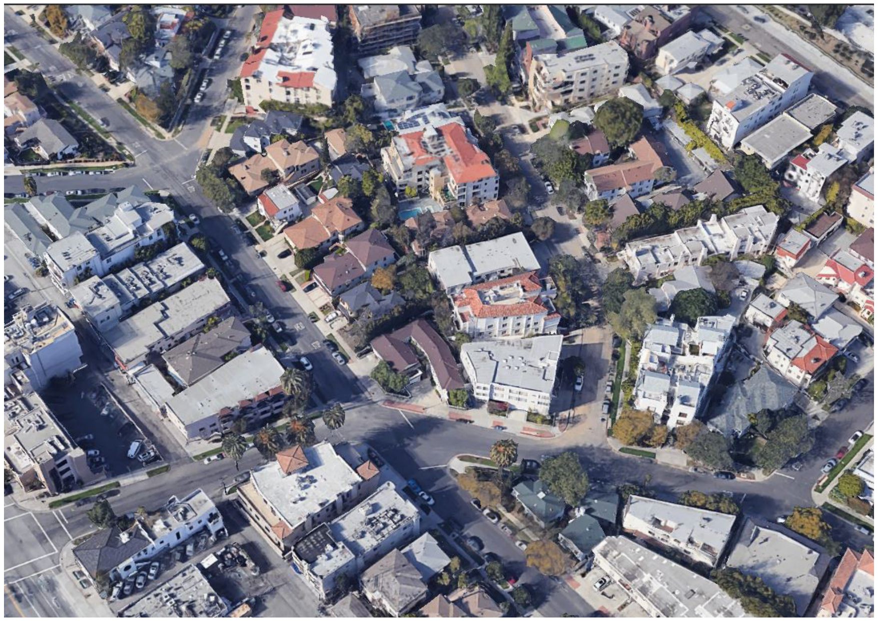
Planning Priorities:

- Designate locations that have the full range of characteristics described for central cities, those planned to evolve to central cities, and new locations for urban centers.
- For new and evolving centers, identify those land use, urban design, and transportation location efficiency elements to be introduced or enhanced in order to increase smart mobility benefits.
- Adopt and apply performance and development standards that encourage high-density, mixed-use infill development such as multimodal LOS and reduced parking requirements.
- Use a flexible approach to design and operations of state highways operating as Main Streets, as described in Caltrans' *Main Streets, California* guide.
- Consider cordon pricing to manage vehicle travel demand and reduce emissions.
- Identify areas that have high "latent" location efficiency; i.e., where land use, urban design patterns, and demographic characteristics could improve smart mobility outcomes if a fuller range of transportation facilities and services were present.
- Address social equity and environmental justice concerns in part through equitable and comprehensive coverage and quality of transportation services.

Transportation Project Priorities:

- Direct service by high capacity and high-speed transit serving local and regional destinations and state-wide destinations
- Creation and improvement of major transportation hubs connecting modes for intercity and international travel as well as intra- and inter-regional movement
- Coordination of transit and related systems to provide convenient multimodal trips
- Pedestrian facilities with high amenity levels
- Extensive network of bicycle facilities
- Shared mobility opportunities
- Complete streets facility treatments
- Limited parking to reduce demand
- Projects providing service, facility, and connectivity improvements to provide an equivalent level of activity connectedness to all population groups
- Design and speed compatibility with surroundings
- Operating strategies to optimize use of existing roadway capacity

Urban Communities



Description: Urban Communities are characterized by medium levels of building heights and population density, with a mix of land uses. While Urban Communities are located adjacent to Central Cities and can generate and support very high traffic volumes and multiple modes of transportation, Urban Communities can also exist outside of urban centers, reducing their regional accessibility factor. Many Urban Communities were built prior to the widespread adoption of automobile use. Thus, they often include walk-and bike-friendly elements, including availability of sidewalks, traffic calming elements, such as street trees, and destinations reachable within convenient travel times by walking or bicycling. Urban Communities can often support high-frequency bus service and in some cases, rail, although these communities typically do not include major transfer stations. The average population density is about 6,000 persons per square kilometer, with high road density and a moderate transit mode share.

Challenges: Freeways and large surface parking lots can create barriers and discourage walking, bicycling, and transit use. Modal conflicts on higher volume corridors, unless appropriate design treatments are in place.

Planning Priorities:

- Designate urban community locations, distinguishing those that have achieved the full range of characteristics described for centers, corridors, or neighborhoods. In these places, maintenance and enhancement of appropriate community design characteristics is the long term goal.
- Designate locations evolving to urban communities from suburban communities or rural places, identifying land use, urban design, and transportation characteristics to be introduced or developed in order to create centers, corridors, and neighborhoods with essential community design elements such as multimodal network connectivity, strong presence of local-serving retail and service uses, and well-integrated public facilities.
- Designate locations for new development with the location-efficient features of urban communities.
- Identify locations where multimodal connectivity to urban centers can be improved.
- Adopt and apply performance and development standards that encourage moderate-density, mixed use infill development, such as multimodal LOS and reduced parking requirements
- Use a flexible approach to design and operations of state highways operating as Main Streets, as described in Caltrans' *Main Streets, California* guide.
- Consider cordon pricing to manage vehicle travel demand and reduce emissions.
- Address social equity and environmental justice concerns in part through equitable and comprehensive coverage and quality of transportation services.

Transportation Project Priorities:

- Pedestrian facilities with high amenity levels
- Extensive network of bicycle facilities
- Convenient opportunities for multimodal transfers and transit transfer
- Design and speed compatibility with surroundings
- Shared mobility opportunities
- Complete streets facility treatments
- Limited parking to reduce demand

Suburban Communities

Description: Suburban communities are low-density, primarily residential, developments. Single occupancy vehicle use is high in suburban communities, which often have limited options for modal choices. Suburban communities may include limited non-residential facilities, usually of only local significance. *Smart Mobility 2010* recommends that Suburban Communities work to transition to Urban Communities through addition of higher density developments and an increased mix of land uses. The average population density is about 2,500 persons per square kilometer, with moderate to low road density an low transit mode share.

Suburban community design includes factors that encourage use of SOV travel and discourages use of other modes. Non-residential destinations are limited or not concentrated in nodes. Intersection density may be low, and bicycle and pedestrian facilities limited or non-existent.

Challenges: By design, suburban communities are often not suitable for non-SOV travel. Typically, transit cannot be supported with low density levels and lack of commercial corridors. Distances between destinations may be too great to support high pedestrian and bicycle mode share.

Planning Priorities:

As the Suburban Community place type is not especially conducive to smart mobility strategies, a key priority is to identify centers and corridors that can be transformed into more location-efficient places. Plan for them in terms of land use, urban design character, and transportation services. Use a flexible approach to design and operations of state highways operating as Main Streets, as described in Caltrans' *Main Streets, California* guide.

Given the high level of public investment and the lengthy time horizon required to stimulate these changes, locations should be prioritized to align with market potential and other community objectives.As for all place types, address social equity and environmental justice concerns in part through equitable and comprehensive coverage and quality of transportation services.

Transportation Project Priorities:

- Improvements to network connectivity to reduce route/trip lengths and opportunities to encourage non-SOV trips
- Complete street facility treatments near schools and areas with an opportunity to transition to Urban Community place types
- Transit, on-demand transit, or rideshare implementation attached to employment centers where appropriate
- Access management and speed management on arterial streets

Rural Areas

Description: Rural areas are characterized by very low building density and large tracts of agricultural or other undeveloped land. Rural areas may include small towns, often comprised of a main street with a few minor supporting street. Single occupancy vehicle use is high in rural areas, however, rural areas can also include households with to zero- or low-vehicle ownership and transit-dependent populations. While the location efficiency of rural areas is low, there are few opportunities to increase this efficiency due to the need to protect and limit development on large swaths of land. Opportunities to employ smart mobility principles are largely concentrated in small town settings. The average population density is about 100 persons per square kilometer, with very low road density and low transit mode share.

Challenges: Long distances between destinations, limiting opportunities for bicycle and pedestrian transportation. Low-density populations, limiting feasibility of transit systems. In agricultural areas, there is a need for connections between the farmland to employee homes or origins, and routes for deliveries or goods exchanges.

Planning Priorities:

- Maintain and create walkable rural towns with streets that are operated and designed for speeds suitable for their context and safety for all users.
- Cluster community-serving uses (public and private) in central areas in rural towns
- Use a flexible approach to design and operations of state highways operating as Main Streets, as described in Caltrans' *Main Streets, California* guide.
- Address social equity and environmental justice concerns in part through equitable and comprehensive coverage and quality of transportation services.

Transportation Project Priorities:

- Bicycle and pedestrian facilities in rural centers/main streets
- Traffic calming in rural centers/main streets
- Trails where public access and recreational use is permitted
- Targeted transit or transit on-demand to accommodate transit-dependent populations/employees/visitors

Protected Lands and Special Use Areas

Description: Protected lands and special use areas are areas designated to a specific single use, such as a nature preserve or military installation. These areas typically have a weak presence of location efficiency factors. Smart mobility approaches for these areas depend on the type and use of the land. Stewardship of natural resources is the primary principle directing Smart Mobility Framework and actions. The Smart Mobility Framework emphasizes the provision of transportation infrastructure to and through protected lands only when consistent with resource preservation and management, or when required for connectivity. Location efficiency dictates that because protected lands have an extremely low level of land use activity there should be a correspondingly low level of investment in transportation infrastructure. Lands protected from development have the following roles in a smart mobility vision:

- Helping to shape development patterns of both urban areas and rural settlements
- Providing natural setting for urban areas with habitat, watershed, and other resource values as well as providing aesthetic value
- Serving as receiving areas for mitigation activities and/ or a sending area for density transfers arising from other place types
- Location of natural hazard where limited or no access is appropriate

Reliability is a factor in those protected lands that are used for resource management or recreation, with a focus on maintaining access through extreme weather events and maintaining roads in good repair for goods movement and an appropriate level of public access.

Places as diverse as military installations, airports, ports, and large industrial zones are included in this place type. This variety means that there is not a consistent smart mobility approach for this place type. The emphasis is on using the full set of principles, decision support tools, and performance measures to craft distinct approaches to each single use area.

In single use areas, location efficiency is typically low by virtue of the fact that these areas will not offer a strong presence of location-efficient community design factors. In fact, adverse impacts generated by some of these areas mean that principles such as public health and safety may best be achieved through separation rather than integration with other activities. When single use places include essential functions with respect to regional and state economies, they may receive high investment priority even if they have low location efficiency.

When single use areas are employment centers that attract workers from surrounding places, such as commercial airports, providing reliable transportation options is a key consideration.

Planning Priorities:

- Capacity and connectivity increases only when required for resource preservation and management and consistent with planned levels of public access.
- Where public access and recreational use is permitted, bicycle facility, and trail projects.
- Connectivity increases through protected lands only when no other options are available to provide required interregional connectivity.

- Access and connectivity needs specific to use and location (such as the need for airports to be highly connected to the surface transportation system for passengers and freight).
- Role of the area as a local, regional, and subregional trip generator of passenger trips or goods movement, particularly during peak hours.
- Issues regarding health, safety, and environmental impacts arising from the particular activities and mobility characteristics of the use (such as health concerns associated with diesel exhaust emissions from traffic generated by port facilities).
- Long-term plans such as decommissioning of military installations or transition away from industrial use. These plans may shift areas presently in single use into a different place type.
- Surrounding context and level of connectedness to surroundings.

Transportation Project Priorities:

- For any lands not fully protected, projects and programs should assure permanent retention in open space/ resource conservation status. Green prints that identify important natural resource lands and working landscapes can provide opportunities to align open space protection efforts with regional blueprints.
- For special use areas, projects are determined by the purpose and context of the special use area.

APPENDIX: RELATED PRODUCTS AND TOOLS

This Guide was developed by ICF and Fehr & Peers under contract with Caltrans. As part of this contract, the consultant team developed several related products and tools, summarized here.

Pedestrian Safety Investigations and Countermeasures Course

A Pedestrian Safety Investigations and Countermeasures training course was developed and delivered. Participants learned how to improve safety for pedestrians at specific locations of concern for collisions on the California State Highway System. Using specific characteristics of each location within the Pedestrian Collision Monitoring Program (including both high collision concentration locations and systemic locations), participants learned to apply the most appropriate treatments from a toolbox of countermeasures. Instruction included both classroom training, field training and practice. The course was customized to California laws and Caltrans Standards, incorporating the unique factors affecting pedestrian planning and engineering for the State Highway System.

The 2-day course was delivered in the following six locations in 2019 and 2020: Caltrans Districts 3, 4, 5, 6, 11, and 12.

Complete Streets Cost Estimating Tool

The consultant team developed the "Planning Complete Streets Cost Estimating Tool". The purpose of this tool is to provide a quick and intuitive cost estimations that can be used in the planning of new active transportation (bicycle and pedestrian) facilities.

The tool uses Basic Engineering Estimating Systems (BEES) items from the Caltrans Cost Database (CCdb) and incorporates bid costs from CCdb to provide estimates that are informed by the most recent costs in Caltrans construction contracts throughout the State. It provides flexible cost templates that the end user can modify to reflect specific project components. The tool is intended to allow cost estimation of complete streets elements such as sidewalks and bicycle facilities as comprised by multiple bid items from the CCdb.

Planning level cost estimates for an entire project that can be broken down by segment, project type, and project elements. The tool features a separate workbook for each Caltrans District, so that unit cost assumptions reflect current assumptions for a chosen geography.

The resulting cost estimation can be used in different phases of the project delivery (Pre-K, K, 0, 1). The output of the tool could be attached to the 11-Page Form and be accessible in the Project History Files.

Action Plan for Pedestrian and Bicyclist Safety in California

The Action Plan for Pedestrian and Bicyclist Safety in California was developed as a roadmap for future pedestrian and bicyclist safety initiatives in the state. It serves as a strategic framework for future actions of the Caltrans Pedestrian and Bicyclist Safety Branch and related actions in other areas of Caltrans. Actions were developed with leadership from the Caltrans project team; with input and consultation with the Technical Advisory Committee; and based on data collection, research, and interviews with knowledgeable personnel within and outside of Caltrans.

The recommended actions in the Action Plan are organized using categories identified in Core Elements for Vision Zero Communities, a nationally recognized best practice for communities seeking to eliminate fatalities and serious injuries. These categories are:

- **Leadership and Commitment.** Includes public, high-level, and ongoing commitment to the goal of eliminating fatalities and injuries; authentic engagement with the community, with a focus on equity; strategic planning including an action plan to guide work; and project delivery, with funding and implementation and prioritization of the most pressing safety issues.
- **Safe Roadways and Safe Speeds.** Includes integration of pedestrian and

bicyclist safety elements for all users into all plans; and context-appropriate speeds, set based on the specific environment and to protect all roadway users.

- **Data-driven Approach, Transparency, and Accountability. I**ncludes equity-focused analysis and programs; proactive, systemic planning; and responsive, hot spot planning. Also includes comprehensive evaluation and adjustments, with routine evaluation of safety performance that informs priorities and budgets.

A technical appendix provides background information collected during development of the Action Plan.

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