CALIFORNIA ACTIVE TRANSPORTATION PLANS

DATA FRAMEWORK AND APPLICATIONS

July 31, 2019

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Disclaimer

This report is intended to be an internal technical resource. It documents the data framework and methodology developed as part of the *Caltrans Active Transportation Plans* study process. This methodology will be applied as part of the prototype District Active Transportation Plan process currently underway. It is anticipated that the methodology (and this report) will be updated based on lessons learned from the prototype process.

EXECUTIVE SUMMARY

CALTRANS ACTIVE TRANSPORTATION METHODOLOGY AND DATA FRAMEWORK

The Caltrans Active Transportation methodology and data framework will help to achieve the vision established in *Toward an Active California*. It will improve safety for everyone, especially people walking and bicycling. It will help to realize aggressive mode shift goals by making it possible for people of all ages and abilities to travel on foot and by bike along and across the State Highway System (SHS). It creates a data-focused approach that is consistent statewide, but that also can be tailored by each Caltrans District to account for local context. The data framework will inform decision-making and improve outcomes in the transportation planning and project delivery process.

The four goals in *Toward an Active California*: Mobility, Safety, Equity, and Preservation, provide the structure for the data framework. Existing statewide datasets are organized by these goals, to reflect, represent, and operationalize the goals in practice. In this way, the goals are used to identify location-based needs and to prioritize them.

The overall process of identifying and prioritizing goals is depicted in Figure ES-1: Caltrans Active Transportation Plan Process.

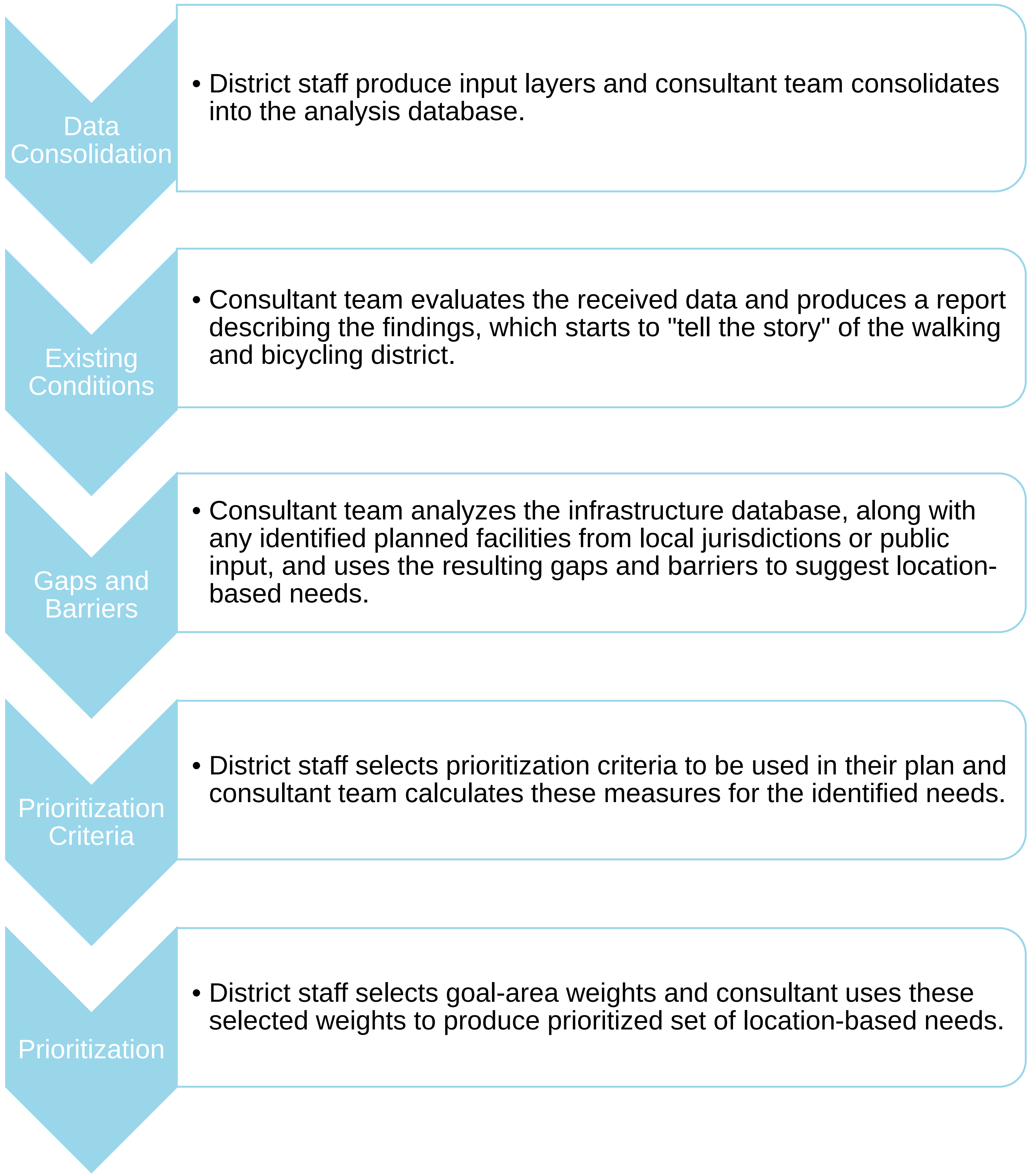

Figure ES-1: Caltrans Active Transportation Plan Process

Step 1: Data Consolidation. The first step of the process is to consolidate data to prepare for the study. Data will be collected regarding infrastructure along the highway system as well as various contextual factors that will be used in orienting the needs identification process and prioritizing needs. This data consolidation effort will result in layers describing conditions for people walking and bicycling along and across the state highway system.

Step 2: Evaluate Existing Conditions. The second step in the data framework is to characterize existing conditions relating to active transportation on the State Highway System. This includes physical characteristics such as the presence of bike lanes and sidewalks and the presence and width of paved shoulders. Using the Active Transportation Asset Inventory Pilot (ATAIP), it also includes the condition of existing assets such as marked crosswalks. It includes operational information such as the speed limit on roadways and safety information, such as the number and location of pedestrian and bicyclist fatalities and serious injuries.

It accounts for existing community characteristics such as destination density, which indicates potential to capture short trips, and demographic characteristics that speak to equity, such as the percentage of children receiving free or reduced school lunches and the percent of low-income households. The purpose of the existing conditions analysis is to inform the identification of location-based needs and engage stakeholders around active transportation needs in each District.

Step 3: Identify Location-Based Needs. The third step is to identify location-based needs across the State Highway System. These needs are identified from a data-driven, systemic perspective. They build on the data collected in the existing conditions phase, accounting for differences between urban and rural contexts, and between the needs for pedestrians, bicyclists, and shared use path users.

The needs identification process is fundamentally built around the Level of Traffic Stress (LTS) methodology, which speaks to the all ages and abilities, safety, and mode shift goals established in *Toward an Active California*. This measure is grounded in research and assumptions made in the analysis process are clearly stated and transparent. In addition to the standard LTS measure, rural-specific measures and pedestrian-oriented measures are also considered to reflect the varied needs of these modes and parties. The location-based needs identification process results in a comprehensive assessment of needs systemwide, ensuring that Caltrans staff can access recommendations for every segment and intersection as upcoming projects are considered, programmed, and implemented. Opportunities for Caltrans staff and stakeholder input can be captured in the needs phase, for example to account for recently completed projects, upcoming projects, and opportunities to identify viable parallel routes.

A detailed summary of how existing context will lead to associated actions system-wide is provided in Table ES-1: Systemic Needs Identification.

<table>
<tr><th>Mode</th><th>Existing Context</th><th>Action</th><th>Notes</th></tr>
<tr><td rowspan="3">Bike</td><td>High Level of Traffic Stress Crossing</td><td>• Improve intersection for bikes.</td><td></td></tr>
<tr><td>High Level of Traffic Stress Corridor (Urban)</td><td rowspan="2">• Add bike facility.
• Upgrade existing bike facility.
• Add paved shoulder.
• Widen exiting paved shoulder.
• Identify parallel route.
• Implement speed management.</td><td rowspan="2">Bike facility type determined by speed/volume thresholds; shoulder is default in rural area; speed management is where there is mismatch to roadway context (e.g. Main Street) and/or crashes</td></tr>
<tr><td>High Level of Traffic Stress Corridor (Rural)</td></tr>
<tr><td rowspan="2">Pedestrian</td><td>Sidewalk Gap Along Pedestrian Route</td><td>• Improve existing sidewalk.
• Add new sidewalk.</td><td>Default is that sidewalks are needed wherever pedestrians are allowed and that sidewalks in poor condition in ATAIP need to be improved</td></tr>
<tr><td>High Pedestrian Level of Traffic Stress (Crossings)</td><td>• Add crosswalk.
• Improve existing crosswalk.
• Add bridge.
• Improve interchange.
• Add pedestrian crossing island.</td><td></td></tr>
<tr><td>Freeway crossings</td><td>Low permeability freeway barriers</td><td>• Add pedestrian and bicycle over/underpass.
• Retrofit interchange to be more pedestrian/bicycle-friendly.</td><td></td></tr>
<tr><td>Shared Use Paths/Trails</td><td>Gap in the trail network</td><td>• Add shared-use path/trails.</td><td>Assumption is that local feedback will be needed for this recommendation</td></tr>
</table>

Table ES-1: Systemic Needs Identification

Step 4: Prioritize Location-Based Needs. The fourth step in the data framework establishes how various active transportation needs across the system relate to each other. The goals from *Toward an Active California* serve as the baseline for this initial prioritization of needs. A layered approach is employed to highlight the areas with the most pressing needs in each district. For example, a corridor that has a high pedestrian and bicycle crash history, significant existing walking and bicycling demand, high opportunity to capture more short trips, and a relatively large percentage of low-income households is a higher priority than a corridor that has none of these characteristics. Similarly, a rural highway that serves as a Main Street or that connects two small towns in close proximity is a higher priority than one that is likely to have less demand for walking and biking.

Needs will be prioritized using a base set of statewide location-based measures, and districts may also select additional measures at their discretion. Table ES-2: Statewide Location-Based Needs Prioritization Criteria summarizes the statewide prioritization criteria.

Table ES-2: Statewide Location-Based Needs Prioritization Criteria

Goal Area	Statewide Measure	Type	Data Source	Methodology
Mobility	Latent Demand	Float	Statewide Travel Demand Model short-trip potential	Project intersect w/ latent demand score polygon
	Adjacency to major transit station	Binary	GIS transit station dataset	Project buffer w/ transit station dataset
Safety	Crash Density	Float	SWITRS	Project intersect w/ moving window results
Equity	CalEnviroScreen population risk score	Float	CalEnviroScreen Population Characteristics score [1]	Project intersect w/ population score polygon
Preservation	Improvement of Existing Asset	Binary	ATAIP	Project comparison to ATAIP

In addition to these statewide measures, Districts may consider optional district criteria, such as those indicated in Table ES-3: Optional District Location-Based Needs Prioritization Criteria. District and stakeholder feedback can be incorporated into the needs prioritization process for example by allowing the public to indicate which of the identified systemic needs are the most important to them.

[1] The CalEnviroScreen Population Characteristics score is the average Sensitive Populations and Socioeconomic Factors component for that census tract

Table ES-3: Optional District Location-Based Needs Prioritization Criteria

Goal Area	Optional District Measure	Data Source
Mobility	Public / stakeholder input on demand	District Plan Public Engagement
	Locally-determined short-trip demand	E.g., Streetlight Data
	Existing bicycle & walk trips	Local bicycle/pedestrian count programs
Safety	Weighted Crash density	SWITRS
	Public / stakeholder input on safety	District Plan Public Engagement
Equity	Locally identified disadvantaged community	E.g., tracts that meet threshold for MPO-defined disadvantaged communities

Statewide datasets will provide a consistent baseline for the initial prioritization; however, District-specific datasets and locally selected measures can be incorporated to reflect local context. Examples could include Districts that have robust pedestrian and bicyclist count data programs or that have data on operating speed of vehicles rather than just the posted speed. The systemic needs identification in the previous step positions Caltrans to react and respond to opportunities that arise, for example, an upcoming corridor project that could potentially add features that will reduce the Level of Traffic Stress for people walking and biking. The initial prioritization of needs begins to position Caltrans to address priority locations in a more proactive way, for example to program countermeasures where clusters of crashes are occurring, which are specifically selected based on the characteristics of the crashes.

To calculate goal area need scores, the first step will be to calculate individual measure scores between 0 (lowest need) and 1 (highest need) for each project. There are two types of measures:

- *Binary* measures are scored either 0 (no) or 1 (yes).
- *Float* measures are scored as a fractional value between 0 (lowest value) and 1 (highest value), based on percentile level of location-based need.

The second step will be to derive goal scores by averaging the individual measure scores within each goal. As an example, if Metrics A and B are selected to represent the Mobility goal, and their scores are 0.0 and 1.0, the Mobility goal score will be 0.5. All preliminary project scoring should be screened by District staff prior to weighting to ensure they are consistent with expectations.

Step 5: Applying Goal Weights. The fifth step in the data framework is to apply a District-specific weighting to the four goal areas. Weighting the goals allows Caltrans to respond to policy and leadership priorities, for example to demonstrate and quantify how equity is elevating specific projects over others. A statewide baseline weighting will be provided, which aligns with the current weighting used in the Active Transportation Program; however, Districts will also have the ability to adjust their weighting to account for local context. This will be accomplished by allowing Districts to scale up or down the weighting of specific goals within a predefined range.

Once weights are defined, cumulative project scores can be normalized into a simple ranking system based on a percentile comparison to other project scores. For example:

- Highest Need: 75th-100th percentile
- High Need: 50th-75th
- Medium Need: 25th-50th
- Low Need: 0 -25th

Step 6: Identify Needs List. The final step in the data framework is to generate a prioritized list of location-based needs that incorporates the results of all previous steps, including existing conditions, systemic needs, prioritized needs, and the application of weights to the initial priorities. The needs list will include high, medium, and low priorities. High priority needs will be referenced and discussed in the final plan; however, all needs will be clearly documented in GIS files that are accessible via the Caltrans Portal. Attributes will be captured for all identified needs, including associated post mile numbers, actions, and the criteria that led to the respective priority rating.

The Caltrans Active Transportation data framework will inform decision-making and improve outcomes, positioning Caltrans to pursue active transportation improvements from both a reactive and a proactive perspective. The results of the analysis process will be generated and displayed with the purpose of feeding directly into the project development and asset management process to, over time, ensure that active transportation needs can compete on equal footing with the needs of other modes. This will help to achieve the vision and operationalize the goals established in *Toward an Active California*.

REPORT OVERVIEW

The remainder of this report describes the technical details of the data framework and needs prioritization methodology. It is organized into the following chapters:

Chapter 1 Data Framework: This chapter describes the database that will be used for the analysis, including details of the data sources for the identified data elements. It also defines responsibilities for data consolidation.

Chapter 2 Gaps and Barriers Identification: The types of gaps and barriers that will be identified on the state highway system are defined in this chapter, as well as the network quality measures to be used.

Chapter 3 Performance Measures: The performance measures described here are used in the needs prioritization process.

Chapter 4 Prioritization Process: This chapter describes the needs prioritization process that will be used to classify the needs.

CHAPTER 1
DATA FRAMEWORK

1. DATA FRAMEWORK

INTRODUCTION

This chapter describes the data management structure and data consolidation process to support active transportation project performance, evaluation, and prioritization activities at the statewide and Caltrans District levels. These activities are being undertaken as a part of the development of Caltrans Active Transportation (CAT) Plans, which are aimed at furthering the goals of *Toward an Active California*, the State Bicycle and Pedestrian Plan adopted in May 2017:

- **Safety** – Reduce the number, rate, and severity of bicycle and pedestrian-involved collisions.
- **Mobility** – Increase walking and bicycling in California.
- **Preservation** – Maintain a high-quality active transportation system.
- **Social Equity** – Invest resources in communities that are most dependent on active transportation and transit.

The CAT Plans are intended to empower staff in Caltrans District offices to be leaders in active transportation through the implementation of a data-driven process to better position location-based needs prioritization, development, and design.

This chapter describes data sources that will be used to populate the overall dataset. Each source's relative merits and anticipated challenges are discussed. Given that there is no complete, statewide network dataset to use for analysis, these pieces must be consolidated into a common database.

A data schema is then presented that will be populated based on various data sources. The data schema is intended to be flexible to accommodate inputs from a number of sources, while supporting the variety of analyses that are anticipated as part of the CAT Plans. The underlying data sources that are used to populate the database may change, but the database will generally remain consistent. Districts may collect supplementary data as necessary. This schema simply provides a basis for comparison statewide. The proposed schema is intended to integrate with existing Caltrans data systems, and to be a dataset that can be maintained beyond the life of this planning effort.

This chapter also describes the general process that will be followed within each District plan to populate the database. The majority of the focus is on populating tables describing assets, as this will require the most coordination and consolidation of data.

While the data schema and process defined here is intended to be comprehensive, additional tables or fields may be added as needed to support specific District requests.

DATA SOURCES

This section describes the datasets that will be used to establish an understanding of existing conditions throughout the SHS in each district and to identify and prioritize location-based needs at these locations.

Existing Statewide Datasets

State Highway Network (SHN)

The State Highway Network (SHN) is a linear referencing system (LRS) dataset for the State Highway System (SHS). It contains geometric information and associated postmiles for all Caltrans-owned facilities throughout the

State and serves as the linking table for geolocating the statewide highway database. This dataset will serve as the basis for all location-based identification of existing assets and needs.

Features	Challenges
• Provides location information for State Highway asset information.	• Does not describe local-roads or freeway crossings.

Transportation System Network (TSN)

Caltrans' Transportation System Network (TSN) contains four main components: an accident inventory database and a highway inventory database (collectively comprising the Traffic Accident Surveillance and Analysis System, or TASAS), Traffic Census, and Traffic Investigation Reporting and Tracking System (TIRTS)[2]. All of these database tables specifically cover details of Caltrans assets. Attribute data about traffic counts and highway segment geometry will be joined from the TSN to the LRS-derived base layer. Highway segment geometry attributes available from TSN include number of lanes, shoulder width, and design speed.

Features	Challenges
• Relevant attribute data: traffic counts, traffic crashes, number of lanes, shoulder width. • Coverage of all Caltrans SHS facilities.	• Database does not include posted or prevailing speeds for SHS facilities; must be sourced from elsewhere, such as District-level inventories or MPO datasets. • Design speed is not a good proxy for posted or prevailing speed, and is known to have inaccuracies. • Shoulder width data may not be well maintained. • Does not contain any information on freeway crossings.

OpenStreetMap

OpenStreetMap (OSM) is a web-based, crowdsourced map of the world. It includes details about roads, buildings, points of interest, and various other features. As crowdsourced data, OSM is inherently limited by the quality of the inputs received from contributors. It sometimes has gaps in attributes, but generally includes details throughout a region and therefore can serve as a source of data when local, regional, or district-level datasets do not contain a particular attribute of interest. The OSM network often has fairly high-quality topological detail, which means that the lines connect in locations where the street network actually connects in real life, and otherwise do not. Topological validity is important when using network data to analyze routing options.

OSM will be used for three primary purposes:

- Identifying and characterizing potential freeway crossing locations
- Assessing barrier permeability of highways based on routing analysis
- Filling gaps in attribute information when more authoritative data is not available

[2] Zhang, Y., Proulx, F. R, Ragland, D. R, Schneider, R. J, & Grembek, O. (2014). Develop a Plan to Collect Pedestrian Infrastructure and Volume Data for Future Incorporation into Caltrans Accident Surveillance and Analysis System Database. UC Berkeley: Safe Transportation Research & Education Center. Retrieved from https://escholarship.org/uc/item/5sm444jz

Features	Challenges
• Contains roadway attribute information for the entire road network. • Has high-quality topology.	• May have substantial data gaps, especially in rural parts of the state.

California Statewide Travel Demand Model

The California Statewide Travel Demand Model (CSTDM) is a tool for estimating and forecasting demand and flows on network links. As part of the modeling process, the CSTDM uses speed estimates and other link-level quantities on the network to allocate forecasted trips onto street segments. These estimates are coarse but may serve as a useful supplement to data from district-level inventories (described below) or OSM, particularly on links without other existing traffic volume estimates. In addition to the network link data, the CSTDM provides zonal estimates of trips produced and attracted by purpose, along with mode share splits. The recently updated CSTDM data is for the 2015 base year.

Features	Challenges
• Contains relevant network attribute data: volumes and speeds by time of day. • Zonal attributes include trips by purpose and mode as well as jobs by industry category. • Large zones (usually comprising 3 to 10 census tracts), approximately 5,000 zones statewide.	• Network is abstract "stick figure" version of the "real" base network, complicating joining attributes from one network to another. • Network is limited to major roadways and ramps and will not include all critical bicycle or pedestrian facilities.

Some census tract boundaries have changed since the TDM zones were established, so not all zones will have a perfect cross-walk nesting of constituent census tracts, and approximate values will need to be calculated based on proportional overlap of the zones.

District-Level Datasets

Active Transportation Asset Inventory Pilot

The Caltrans Active Transportation Asset Inventory Pilot (ATAIP) is an effort to collect bicycle and pedestrian infrastructure data along state highways. Caltrans HQ created geometries for sidewalks, crosswalks, and bicycle facilities for the state highway system, and has called upon District staff to populate various attribute information for these facilities on the roads within their district. An ArcGIS Online web application has also been created to streamline the data observation and attribute population process, integrating web-based imagery with the form used to fill in details about the infrastructure.

Features	Challenges
• The most current inventory of active transportation infrastructure available. • Consistent data schema across districts. • Includes fields describing infrastructure condition.	• Only for SHS segments, not for surrounding areas. • Does not cover freeways. • Depends on District staff completing their inventories in advance of plan kickoff.

Transportation Concept Reports (TCRs)

Every route in every district has a completed Transportation Concept Report (TCR). TCRs are 20-25 year planning documents detailing the existing corridor context for reach route and a vision for the future for these routes. These descriptions include discussion of elements related to active transportation, both in terms of existing conditions and difficulties and in terms of relevant planned and programmed projects.

Features	Challenges
• Very detailed look at corridor context for every single route. • Has information on pedestrian and bicycle crossings of freeways, not available in any other commonly available location.	• Reports are stored in PDF form – requires transcription of relevant data. • TCRs are updated on a five-year cycle; may be out of date. • Considerations for the specific needs of people walking and bicycling may vary by district.

District-Level Inventories

Some Districts may have additional inventories of network variables that could inform analyses for their plans. For instance, during the District 4 Bike Plan, a posted speed inventory was identified that contained more accurate posted speed limits for the state highways than was available in TASAS-TSN. District staff will be engaged prior to their plan kickoff to identify whether any additional datasets are available that they would like to integrate into the planning process.

Features	Challenges
• Potentially more curated data than is available statewide. • Consistent data format across the district.	• Likely only contains detail about mainline conditions. • Differences between districts in terms of what is available.

Local/Regional Datasets

Existing Bicycle/Pedestrian Conditions from MPO/Regions

Municipal Planning Organizations (MPOs) and other regional governments often have consolidated network datasets, particularly for bicycle facilities. This information will be critical for understanding bicycling conditions on facilities adjacent to or crossing the state highway system, as updated data will not be collected for these locations as part of the ATAIP. Some regions may also have complete pedestrian facility inventories that can be used to populate the asset database for local roads. Collecting this data from regional entities will reduce the amount of data translation needed to get the received datasets into the CAT Plan data framework. However, given the potential variability in data quality, these regional datasets will need to be assessed for completeness and timeliness.

Features	Challenges
• Data from local jurisdictions that has already been consolidated into a consistent GIS data schema.	• Regional/MPO data may not always be as current as local data, and therefore may require additional editing. • Datasets with overlapping jurisdictional boundaries may not be consistent. This is particularly a problem for routes that frequently traverse District boundaries.

Existing Bicycle/Pedestrian Asset Data from Local Governments

Most likely agencies to maintain data on facilities under their jurisdiction. The consultant team knows that most larger cities and larger or predominantly urban counties store their bicycle facility data in GIS formats, which will facilitate consolidation into a single database. Smaller towns and rural counties are less likely to maintain standalone bicycle inventories, given the small number of facilities that exist in these locales.

To accommodate this, the project team will develop an Excel workbook that local agencies can complete to indicate the locations and characteristics of their bicycle facilities in the vicinity of state highways based on the ARNOLD linear referencing system and associated postmile information.

Features	Challenges
• City and county datasets are likely to be the most complete and up-to-date record of bicycle facility existing conditions for non-SHS locations.	• With over 480 municipalities and 58 counties throughout the state, there are a potentially overwhelming number of files to be consolidated. • Variations in formats can introduce substantial challenges to this process. For instance, some cities may hold separate geometric features for each direction of a bicycle lanes on a single street, while others may store this information as separate attributes on a single geometry.

Planned Bicycle/Pedestrian Assets

While cities and counties do not typically build active transportation facilities on Caltrans-owned facilities, many of their plans include recommendations that intersect with Caltrans facilities, either as crossings of access-controlled facilities or at critical locations on surface highways. These proposed facilities will serve as a starting point for the identification of needs for the CAT plans, as they have already been developed in other planning efforts.

Proposed facilities from local and regional efforts may be in a wide range of formats, either tracked in GIS-based facility inventories, recorded in PDF plan documents as individual detailed pages, or in tabular form in the appendix of plan documents.

Features	Challenges
• Proposed facilities will provide a convenient starting point for identifying needs for the Caltrans system.	• Similar to the consolidation of existing conditions data, the variety of formats that might be encountered could make consolidating these datasets a significant task.

DATA SCHEMA

The proposed data schema consists of:

1. Linear referenced highway active transportation layers describing existing conditions along and across the highways.
2. Needs layers identifying where gaps and barriers may need addressing.
3. Contextual layers containing additional variables that will be joined to the needs for prioritization purposes, such as identifying disadvantaged communities and locations with a crash history. These layers will all be used as received, so no data consolidation nor specification of a schema is necessary.

The project team will base the geometries for the highways on the State Highway Network (SHN) layer, which contains linear referencing system (LRS) data for all state highways. This layer, in conjunction with TASAS-TSN, provides critical information about operating conditions along the state highways and at ramps and intersections. However, this database does not contain comprehensive information about active transportation assets, crossing opportunities on freeways, nor does it hold all roadway variables that may be desired for needs identification. Accordingly, it will be supplemented with data from various other sources, including the Active Transportation Asset Inventory Pilot (ATAIP), OpenStreetMap (OSM), District-level datasets, and partner agency datasets.

The data describing these locations will be stored in five key tables:

1. State Highway Linear Active Transportation Assets (linear_at_assets) primarily describes the active transportation experience along state highways, including presence of active transportation facilities, other contextual roadway data, and identified alternate routes where appropriate.
2. Conventional State Highway Crossing Opportunities (conventional_crossings) describes crossing locations on conventional surface highways. This table is based primarily on the TASAS-TSN intersections table.
3. Freeway Crossing Opportunities (freeway_crossings) describes locations that potentially offer the option for people walking and bicycling to cross freeways, either at interchanges or dedicated pedestrian or bicycle over/undercrossings and characterizes these crossings in terms of stress-related variables.
4. Linear Active Transportation Needs (linear_at_needs) describes corridor-level needs that would primarily facilitate travel along the SHS, including prioritization information.
5. Point Active Transportation Needs (point_at_needs) describes point-based needs that would primarily facilitate travel across the SHS, including prioritization information.

The schemas describing these layers are presented in Tables 1-5.

Table 1-1: State Highway Linear Active Transportation Assets

Key†	Field	Data Type‡	Description	Source
	district			TASAS-TSN
PK	county		County where segment lies	TASAS-TSN
PK	route	Char(3)	Route number	TASAS-TSN
PK	route_sfx	Char(1)	Route suffix	TASAS-TSN
PK	Pm_pfx		Postmile Prefix	
PK	Begin_pm		Beginning Postmile, following TASAS convention	
PK	End_pm		End Postmile, following TASAS convention	
PK	Pm_sfx		Postmile Suffix	

PK	Observation_date	Timestamp	Date Associated with Record Creation	
	Median_type			TASAS-TSN
	Median_width			TASAS-TSN
	Current_adt	Integer	Current Average Daily Traffic	TASAS-TSN
	thy_highway_access_code	Text	Highway Type – Conventional, Expressway, or Freeway	TASAS-TSN
	Rural_urban	Text	Rural or Urban	TASAS-TSN
	Rt_lanes	Integer	Number of lanes on right alignment	TASAS-TSN
	Lt_lanes	Integer	Number of lanes on left alignment	TASAS-TSN
	thy_rt_o_shd_tot_width_amt	Integer	Right outer shoulder total width (feet)	TASAS-TSN
	thy_rt_o_shd_trt_width_amt	Integer	Right outer shoulder paved width (feet)	TASAS-TSN
	thy_lt_o_shd_tot_width_amt	Integer	Left outer shoulder total width (feet)	TASAS-TSN
	thy_lt_o_shd_trt_width_amt	Integer	Left outer shoulder paved width (feet)	TASAS-TSN
	Bikeaccess	Text	Bicyclists prohibited/not prohibited	Caltrans HQ GIS
FK	Bike_smat_id	Varchar(254)	Linking ID to ATAIP Bike Lane table	ATAIP Bike Lane table
	Bike_condition	Text	Condition of bicycle facility – Values include 'Good', 'Fair', 'Poor', 'Unknown', and 'No Facility'	ATAIP Bike Lane table
	Bike_type	Text	Bike Facility Condition – Values include 'Class I', 'Class II', 'Class II Buffered', 'Class III', 'Class IV', 'Unknown', and 'No Facility'	ATAIP Bike Lane table
	Bike_width	Integer	Width of bicycle facility (feet)	ATAIP Bike Lane table
	Bike_comments	Varchar(255)	Comments describing bike facility	ATAIP Bike Lane table
FK	Sw_smat_id	Varchar(10)	Linking ID to ATAIP Sidewalk table	
	Sw_condition	Text	Condition of sidewalk – Values include 'Good', 'Fair', 'Poor', 'Unknown', and 'No Sidewalk'	ATAIP Sidewalks table
	Speed	Integer	Posted speed on segment (mph)	Local agencies; Speed zone layers
	Speed_source	Text	Description of source for the speed data	
	Current_bike_lts	Integer	Current bicycle level of traffic stress along highway	Calculated
	Current_pedestrian_lts	Integer	Current pedestrian level of traffic stress along highway	Calculated
	Geometry	LineString		

†Describes relationships of tables within database. PK=Primary Key, the combination of these columns makes a unique identifier. FK=Foreign Key, this key links to a primary key on another table.
‡Data types follow standard definitions, including Boolean=a true/false field; Varchar= a text field of varying length, up to the number of characters specified in parentheses, Float=A number with decimal places

Table 1-2: Conventional State Highway Crossing Opportunities

Key	Field	Data Type	Description	Source
	district			TASAS-TSN
PK	county		County where segment lies	TASAS-TSN
PK	route	Char(3)	Route number	TASAS-TSN
PK	route_sfx	Char(1)	Route suffix	TASAS-TSN
PK	Pm_pfx		Postmile Prefix	
PK	Postmile		Postmile, following TASAS convention	
PK	Pm_sfx		Postmile Suffix	
PK	Observation_date	Timestamp	Date Associated with Record Creation	
	Inx_intersection_name	Text	Intersection Name	TASAS-TSN
	Inx_design_code	Text	Intersection Design	TASAS-TSN
	Median_type			TASAS-TSN
	Median_width			TASAS-TSN
	Inx_mainline_adt	Integer	Current Average Daily Traffic on mainline	TASAS-TSN
	Inx_xstreet_adt	Integer	Current Average Daily Traffic on cross-street	TASAS-TSN
	Inx_main_lanes_amt	Integer	Number of through-lanes on mainline	TASAS-TSN
	Inx_main_left_channel_code	Text	Description of left-turn lanes on mainline	TASAS-TSN
	Inx_main_right_channel_code	Text	Description of right-turn lanes on mainline	TASAS-TSN
	Inx_cross_lanes_amt	Integer	Number of through-lanes on cross-street	TASAS-TSN
	Inx_cross_left_channel_code	Text	Description of left-turn lanes on cross-street	TASAS-TSN
	Inx_cross_right_channel_code	Text	Description of right-turn lanes on cross-street	TASAS-TSN
	Inx_control_code	Text	Description of intersection control	TASAS-TSN
	Inx_main_flow_code			
	thy_highway_access_code	Text	Highway Type – Conventional, Expressway, or Freeway	TASAS-TSN
	Rural_urban	Text	Rural or Urban	TASAS-TSN
	thy_rt_o_shd_tot_width_amt	Integer	Right outer shoulder total width (feet)	TASAS-TSN

	thy_rt_o_shd_trt_width_amt	Integer	Right outer shoulder paved width (feet)	TASAS-TSN
	thy_lt_o_shd_tot_width_amt	Integer	Left outer shoulder total width (feet)	TASAS-TSN
	thy_lt_o_shd_trt_width_amt	Integer	Left outer shoulder paved width (feet)	TASAS-TSN
	Bikeaccess	Text	Bicyclists prohibited/not prohibited	Caltrans HQ GIS
	Inx_main_speed	Integer	Posted speed on mainline segment (mph)	Local agencies; Speed zone layers
	Inx_main_speed_source	Text	Description of source for the speed data	
	Inx_cross_speed	Integer	Posted speed on crossing street (mph)	Local agencies
	Inx_cross_speed_source	Text	Description of source for cross-street speed data	
	Crosswalk_main_1_condition	Text	Condition for first crosswalk across mainline	ATAIP
	Crosswalk_main_1_type	Text	Type of first crosswalk across mainline	ATAIP
	Crosswalk_main_1_color	Text	Color of first crosswalk across mainline	ATAIP
	Crosswalk_main_2_condition	Text	Condition for second crosswalk across mainline	ATAIP
	Crosswalk_main_2_type	Text	Type of second crosswalk across mainline	ATAIP
	Crosswalk_main_2_color	Text	Color of second crosswalk across mainline	ATAIP
	Crosswalk_main_3_condition	Text	Condition for third crosswalk across mainline	ATAIP
	Crosswalk_main_3_type	Text	Type of third crosswalk across mainline	ATAIP
	Crosswalk_main_3_color	Text	Color of third crosswalk across mainline	ATAIP
	Crosswalk_xstreet_1_condition	Text	Condition for first crosswalk along mainline	ATAIP
	Crosswalk_xstreet _1_type	Text	Type of first crosswalk along mainline	ATAIP
	Crosswalk_xstreet _1_color	Text	Color of first crosswalk along mainline	ATAIP
	Crosswalk_xstreet _2_condition	Text	Condition for second crosswalk along mainline	ATAIP
	Crosswalk_xstreet _2_type	Text	Type of second crosswalk along mainline	ATAIP
	Crosswalk_xstreet _2_color	Text	Color of second crosswalk along mainline	ATAIP

	Crosswalk_xstreet _3_condition	Text	Condition for third crosswalk along mainline	ATAIP
	Crosswalk_xstreet _3_type	Text	Type of third crosswalk along mainline	ATAIP
	Crosswalk_xstreet _3_color	Text	Color of third crosswalk along mainline	ATAIP
	Current_bike_lts	Integer	Current bicycle level of traffic stress across highway	Calculated
	Current_pedestrian_lts	Integer	Current pedestrian level of traffic stress across highway	Calculated
	Geometry	Point		

Crossings of freeways warrant their own table, as the constraints and challenges at these locations are distinct from those of conventional highway crossings. The attributes to be stored for these locations are described below.

Table 1-3: Freeway Crossings

Key	Field	Data Type	Description	Source
	district			TASAS-TSN
PK	county		County where segment lies	TASAS-TSN
PK	route	Char(3)	Route number	TASAS-TSN
PK	route_sfx	Char(1)	Route suffix	TASAS-TSN
PK	Pm_pfx		Postmile Prefix	
PK	Postmile		Postmile, following TASAS convention	
PK	Pm_sfx		Postmile Suffix	
PK	Observation_date	Timestamp	Date Associated with Record Creation	
	Functional classification	Integer	Functional classification of crossing, following FHWA convention. 8=Multi-use trail	OpenStreetMap
	Ramp_1_onoff	Text	On/off ramp for first identified ramp intersecting with freeway crossing	TASAS-TSN
	Ramp_1_cw_type	Text	Type of Crosswalk. Values include 'Continental', 'Ladder', 'Standard', 'Unknown', 'Other', and Null	
	Ramp_1_cw_condition	Text	'Good', 'Fair', and 'Poor', following ATAIP guidelines	
	Ramp_1_cw_color	Text	White, yellow	
	Ramp_1_ADT	Text	AADT of first identified intersecting ramp	TASAS-TSN
	Ramp_1_type	Text	Ramp type for first identified ramp	TASAS-TSN
	Ramp_1_ctrl	Text	Traffic control for first identified ramp intersecting with freeway crossing	TASAS-TSN
	Ramp_2_onoff	Text	On/off for intersecting ramp	TASAS-TSN
	Ramp_2_cw_type	Text	Type of Crosswalk. Values include 'Continental', 'Ladder', 'Standard', 'Unknown', 'Other', and Null	
	Ramp_2_cw_condition	Text	'Good', 'Fair', and 'Poor', following ATAIP guidelines	

	Ramp_2_cw_color	Text	White, yellow	
	Ramp_2_adt	Text	ADT of intersecting ramp	TASAS-TSN
	Ramp_2_type	Text	Ramp type for first identified ramp	TASAS-TSN
	Ramp_2_ctrl	Text	Traffic control for first identified ramp intersecting with freeway crossing	TASAS-TSN
	Ramp_3_onoff	Text	On/off for intersecting ramp	TASAS-TSN
	Ramp_3_cw_type	Text	Type of Crosswalk. Values include ‘Continental’, ‘Ladder’, ‘Standard’, ‘Unknown’, ‘Other’, and Null	
	Ramp_3_cw_condition	Text	‘Good’, ‘Fair’, and ‘Poor’, following ATAIP guidelines	
	Ramp_3_cw_color	Text	White, yellow	
	Ramp_3_adt	Text	ADT of intersecting ramp	TASAS-TSN
	Ramp_3_type	Text	Ramp type for first identified ramp	TASAS-TSN
	Ramp_3_ctrl	Text	Traffic control for first identified ramp intersecting with freeway crossing	TASAS-TSN
	Ramp_4_onoff	Text	On/off for intersecting ramp	TASAS-TSN
	Ramp_4_cw_type	Text	Type of Crosswalk. Values include ‘Continental’, ‘Ladder’, ‘Standard’, ‘Unknown’, ‘Other’, and Null	
	Ramp_4_cw_condition	Text	‘Good’, ‘Fair’, and ‘Poor’, following ATAIP guidelines	
	Ramp_4_cw_color	Text	White, yellow	
	Ramp_4_adt	Text	ADT of intersecting ramp	TASAS-TSN
	Ramp_4_type	Text	Ramp type for first identified ramp	TASAS-TSN
	Ramp_4_ctrl	Text	Traffic control for first identified ramp intersecting with freeway crossing	TASAS-TSN
	Sw_condition_1	Text	Condition of sidewalk – Values include ‘Good’, ‘Fair’, ‘Poor’, ‘Unknown’, and ‘No Sidewalk’	
	Sw_condition_2	Text	Condition of sidewalk – Values include ‘Good’, ‘Fair’, ‘Poor’, ‘Unknown’, and ‘No Sidewalk’	
	Speed	Integer	Posted speed on crossing segment (mph)	Local agencies; OSM; Inferred
	Speed_source	Text	Description of speed data source	
	lanes	Integer	Number of through-lanes on crossing facility	Local agencies; OSM
	Lanes_source	Text	Description of source of lane data	
	Ped_notes	Text	Noted issues for pedestrian crossings	
	Bike_notes	Text	Noted issues for bicycle crossings	

The table below summarizes the core fields for the linear active transportation needs table. In addition to these fields, values summarizing the selected performance measures in each district will be added on a District-by-District basis.

Table 1-4: Linear Active Transportation Needs

Key	Field	Data Type	Description
	district		
PK	county		County where segment lies
PK	route	Char(3)	Route number
PK	route_sfx	Char(1)	Route suffix
PK	Pm_pfx		Postmile Prefix
PK	Begin_pm		Beginning Postmile, following TASAS convention
PK	End_pm		End Postmile, following TASAS convention
PK	Pm_sfx		Postmile Suffix
PK	Observation_date	Timestamp	Date Associated with Record Creation
	Gap_type	Text	Type of gap or barrier identified
	Need_type	Text	Type of need at this location. Values include: “Add new sidewalk”, “improve existing sidewalk”, “Class I bikeway/shared-use path”, “Class II bikeway”, “Class II buffered Bikeway”, “Class III Bikeway”, “Class IV Bikeway”, “Add Paved Shoulder”, “Widen Existing Paved Shoulder”, “Identify Parallel Route”, and “Implement Speed Management”
	Need_source	Text	General description of where the need was initially defined. Values include “Assumed”, “District staff”, “Local Plan”, “Public Input”, and “Other’. “Assumed” refers to needs that are suggested directly in response to the existing conditions and gaps/barriers analysis without additional refinement
	Need_desc	Text	Detailed description of need
	Mobility_score	Float	Overall mobility score. Range between 0 and 1, where 1 is highest need in the district.
	Safety_score	Float	Overall safety score. Range between 0 and 1, where 1 is highest need in the district.

	Equity_score	Float	Overall equity score. Range between 0 and 1, where 1 is highest need in the district.
	Preservation_score	Float	Overall preservation score. Range between 0 and 1, where 1 is highest need in the district.
	Overall_score	Float	Total combined score based on district-defined weights.
	Need_tier	Integer	Level of need based on results of prioritization process

In addition to "linear" needs along the SHS, "point" needs will be identified at specific locations. These are generally crossing improvements that will facilitate movement of people walking and bicycling across the highway. Table 1-5: Point Needs displays the schema for this data. Similarly to for the linear needs, additional fields will be added at the District-level to summarize the prioritization measures at the needs level.

Table 1-5: Point Needs

Key	Field	Data Type	Description
	district	Integer	Caltrans District number
PK	county	Char(3)	County where segment lies, using 3 digit acronym
PK	route	Char(3)	Route number
PK	route_sfx	Char(1)	Route suffix
PK	Pm_pfx		Postmile Prefix
PK	postmile		Postmile for need, following TASAS convention
PK	Pm_sfx		Postmile Suffix
PK	Observation_date	Timestamp	Date Associated with Record Creation
	Gap_type	Text	Type of gap or barrier identified
	Need_type	Text	Type of need at this location. Values include "install standard crosswalk", "install crosswalk with additional safety enhancements", "add safety enhancements to existing crosswalk", "restripe existing crosswalk", "add pedestrian/bicycle bridge", "add bicycle crossing enhancements at intersection", "interchange retrofit", and
	Need_source	Text	General description of where the need was initially defined. Possible values include "Assumed", "District staff", "Local Plan", "Public Input", and "Other'. "Assumed" refers to needs that

			are suggested directly in response to the existing conditions and gaps/barriers analysis without additional refinement
	Need_desc	Text	Detailed description of need
	Mobility_score	Float	Overall mobility score. Range between 0 and 1, where 1 is highest need in the district.
	Safety_score	Float	Overall safety score. Range between 0 and 1, where 1 is highest need in the district.
	Equity_score	Float	Overall equity score. Range between 0 and 1, where 1 is highest need in the district.
	Preservation_score	Float	Overall preservation score. Range between 0 and 1, where 1 is highest need in the district.
	Overall_score	Float	Total combined score based on district-defined weights.
	Need_tier	Integer	Level of need, based on results of prioritization process

The primary focus is on the development of the network dataset, as statewide data is most limited for this component of the analysis framework and therefore substantial attention will need to be given to attaining data from local jurisdictions. All other datasets will require minimal processing before they can be incorporated into the data management framework.

Each anticipated source of data is explained below, and roles and responsibilities are defined for various parties involved in the project including Caltrans Headquarters (HQ) staff, Caltrans District staff, and the project team. These anticipated roles are defined both for overall statewide considerations and for the data consolidation process within each district plan.

DATA CONSOLIDATION PROCESS

This section details the steps that will be taken within each District-level plan to consolidate the received data into a consistent set of layers, organized by the responsible party. The “base” layer for highway features will be the State Highway Network (SHN). Other geographically referenced roadway environment layers, such as crossing locations, will be based on this. This process focuses on asset information, as all of the prioritization data is available in a ready to use format.

Caltrans HQ Responsibilities

1. Digitize ATAIP data.
2. Provide updated TSN data, if any elements have changed, within 2 weeks of project start.

Local Agency Representative Responsibilities

1. Work with Caltrans district staff to assemble requested datasets. These can be assembled in either GIS or tabular format with postmile references.

2. Review existing network data, once compiled, to verify accuracy.

District Responsibilities

1. Prior to plan inception, coordinate with local agencies (MPOs, counties, cities) to identify existing conditions datasets.
2. Review local agency planned projects and code them into linear and point needs tables.
3. Prior to plan inception, complete ATAIP data collection.
4. Populate/update freeway crossings table (produced by consultant) with information about crossings. Information can be pulled from TCRs, local datasets, and/or field evaluation.
5. At plan inception, provide all supplemental datasets to consultant. These may cover conditions that are not otherwise represented in statewide databases.
6. Review existing network and correct errors.

Consultant Responsibilities

1. At plan inception, pull OSM data and clip to District extents for use in filling data gaps.
2. Geolocate TSN intersection and ramp data using LRS.
3. Identify potential freeway crossing locations using OSM data and populate attributes based on OSM and TSN layers. Provide layer to District staff to add additional detail based on TCRs, aerial imagery evaluation, and local knowledge.
4. Join ATAIP bicycle facility and sidewalk data to SHN, filling intersection gaps for planning purposes.
5. Join ATAIP crosswalks to intersections using a spatial join.
6. Join any supplemental highway data received from district staff and/or local agency partners to master highway files.

After this data consolidation process is complete, the asset layers can be used for gaps and barriers evaluation. The success of this process depends heavily on District staff participation in completing the ATAIP data collection, assisting with identifying freeway crossing characteristics, and assembling projects from local agency plans.

CHAPTER 2
GAPS AND BARRIERS IDENTIFICATION

2. GAPS AND BARRIERS IDENTIFICATION

This chapter describes the identification of gaps and barriers throughout the State Highway System, which will serve as the basis for location-based needs. These needs are identified from a data-driven, systemic perspective. They build on the data collected in the existing conditions phase, accounting for differences between urban and rural contexts, and between the needs for pedestrians, bicyclists, and shared use path users. Following the identification of these needs, they will be prioritized based on statewide and locally-identified prioritization criteria and goal weights.

The needs identification process is fundamentally built around the Level of Traffic Stress (LTS) methodology, which speaks to the all ages and abilities, safety, and mode shift goals established in *Toward an Active California*. This measure is grounded in research and assumptions made in the analysis process are clearly stated and transparent. In addition to the standard LTS measure, rural-specific measures and pedestrian-oriented measures are also considered to reflect the varied needs of these modes and parties. The location-based needs identification process results in a comprehensive assessment of needs systemwide, ensuring that Caltrans staff can access recommendations for every segment and intersection as upcoming projects are considered, programmed, and implemented. Opportunities for Caltrans staff and stakeholder input can be captured in the needs phase, for example to account for recently completed projects, upcoming projects, projects led by partner agencies, and opportunities to identify viable parallel routes.

This chapter will first describe the approach to the network quality measures defined above and will then go into additional detail on the specific types of gaps and barriers and the types of countermeasures that may be appropriate for each of them.

NETWORK MEASURES

For bicycle and pedestrian travel, the level of comfort for the people making trips is almost as important as network existence, so the measures proposed here incorporate facility quality evaluations where possible.

Bicycle Level of Traffic Stress

Bicycle Level of Traffic Stress (BLTS) is based on research by Roger Geller[3], Jennifer Dill[4], and others[5]. This research demonstrates that while avid bicyclists are accustomed to interacting with motor vehicle traffic, most people have little tolerance for interacting with traffic while riding a bike and are very worried about being struck by a motor vehicle. In fact, these concerns discourage many people from choosing to bike. The share of people that are interested in biking but concerned about traffic comprise 51 to 56 percent of the population (avid or confident bicyclists comprise 12 to 13 percent, and the remainder have no interest in riding a bike). They prefer quiet streets, trails, and other "low stress" places to bike that have limited motor vehicle traffic or are separated from traffic.

[3] Geller, R (2006). Four Types of Cyclists, Portland Bureau of Transportation, Portland, OR. http://www.portlandoregon.gov/transportation/article/264746. Accessed 4 December 2018.
[4] Dill, J., and N. McNeil (2013). Four Types of Cyclists? Examination of Typology for Better Understanding of Bicycling Behavior and Potential. Transportation Research Record: Journal of the Transportation Research Board, No. 2387, pp. 129–138. DOI: 10.3141/2387-15
[5] Maaza C. Mekuria, Peter G. Furth, and Hilary Nixon. "Low-Stress Bicycling and Network Connectivity" Mineta Transportation Institute Publications (2012). Available from https://scholarworks.sjsu.edu/mti_publications/74/. Accessed 4 December 2018.

BLTS defines four levels of street classification, which are designed to roughly map onto the four “types” of cyclists hypothesized by Geller:

- LTS 1 facilities are comfortable for people of all ages and abilities, including children.
- LTS 2 streets are comfortable for most adults, including people that are interested but concerned about bicycling.
- LTS 3 are comfortable for those who are confident bicyclists.
- LTS 4 streets are the most stressful classification and are uncomfortable for most people except for those who are very confident bicyclists.

These factors are determined by characteristics of the streets in question, such as speed limits, the amount of motor vehicle traffic, number of travel lanes, and bikeway design elements. BLTS has been validated in a small number of studies, including findings that while commute mode share is not significantly associated with low-stress accessibility in the study area, there is a significant association between low-stress accessibility and overall household bicycle trip production.[6] Similarly, additional research has found that roadway environments with high BLTS ratings are associated with increased bicycle crash severity.[7]

BLTS is not the only measure for assessing “quality” of network segments and intersections. For instance, the Highway Capacity Manual’s Bicycle Level of Service (BLOS) is an alternative that is sometimes used. BLTS will be used here for the following reasons:

- The trade-offs between how different variables affect BLOS are based on a study that was performed with a relatively limited sample of respondents and in a limited geographic context.
- BLOS is considerably more complex in application, and therefore more difficult to communicate the results of.
- BLTS is more widely used in practice than BLOS.

Unit of Analysis: Segments and intersection crossings.

Required Data Inputs: BLTS requires a relatively comprehensive network dataset to be applied in full. However, recognizing that these details are not always available, assumptions for missing data will be made based on the known characteristics of the segments in question and known values for similar segments in the dataset. To be fully applied as described here, BLTS requires the following:

Segment-level data:

- Functional class
- Number of lanes
- Indicator of one-way or two-way street
- Average Annual Daily Traffic (AADT)
- Indicator of centerline presence
- Posted Speed
- Parking

[6] Wang, H., Palm, M., Chen, C., Vogt, R., & Wang, Y. (2016). Does bicycle network level of traffic stress (LTS) explain bicycle travel behavior? Mixed results from an Oregon case study. *Journal of transport geography*, *57*, 8-18.
[7] Chen, C., Anderson, J. C., Wang, H., Wang, Y., Vogt, R., & Hernandez, S. (2017). How bicycle level of traffic stress correlate with reported cyclist accidents injury severities: A geospatial and mixed logit analysis. *Accident Analysis and Prevention*, *108*, 234-244.

- Parking width
- Bike infrastructure
- Bike lane width
- Paved shoulder width

Crossing data:

- Functional class
- Control type (stop, signal, Rectangular Rapid Flashing Beacon, hawk signal)
- Presence or absence of crossing island
- Number of lanes
- Speed

Desirable Additional Data Inputs: To be applied in full as originally described, BLTS also requires detailed information on the geometric design of the right turn lanes approaching each intersection. However, given the scale of this effort, that data is unlikely to be available.

What It Tells Us: Bicycle level of traffic stress provides an understanding of comfort conditions for people bicycling on the network. It can be used on face-value to identify locations that are “high stress” (typically BLTS 3-4). It can also be used as a component in assessing network connectivity by restricting the network to “low-stress” facilities (typically BLTS 1-2). This analysis results in a BLTS rating for each street segment, by direction.

How it is calculated: BLTS is evaluated based on the lookup tables depicted in Tables 1 through 3 (adapted from Mineta Institute research[8]). Roads without bike lanes (i.e., mixed traffic, shown in Table 1) are categorized based on how many travel lanes are present, typical traffic volumes, and travel speeds or speed limits. Low volume, low speed roads are categorized as having a lower level of traffic stress than segments with higher volumes or higher speeds.

[8] http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables-v2-June-1.pdf

Table 2-1: Mixed Traffic Criteria[9]

Number of lanes	Effective ADT*	Speed Limit[10] ≤ 20 mph	25 mph	30 mph	35 mph	40 mph	45 mph	50+mph
Unlaned 2-way street (no centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751-1500	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
	1501-3000	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4	LTS 4
	3000+	LTS 2	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
1 thru lane per direction (1-way, 1-lane street or 2-way street with centerline)	0-750	LTS 1	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	751-1500	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
	1501+	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4
2 thru lanes per direction	0-8000	LTS 3	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4
	8001+	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4
3+ thru lanes per direction	any ADT	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4	LTS 4	LTS 4

* Effective ADT = ADT for two-way roads; Effective ADT = 1.67*ADT for one-way roads

Table 2-2: Bike Lanes and Shoulders Not Adjacent to a Parking Lane[11]

Number of lanes	Bike Lane Width	Speed Limit[12] ≤ 25 mph	30 mph	35 mph	40 mph	45 mph	50+ mph
1 thru lane per direction, or unlaned	6+ ft	LTS 1	LTS 1	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 4
2 thru lanes per direction	6+ ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 3	LTS 3
	4 or 5 ft	LTS 2	LTS 2	LTS 2	LTS 3	LTS 4	LTS 4
3+ lanes per direction	any width	LTS 3	LTS 3	LTS 3	LTS 4	LTS 4	LTS 4

1. If bike lane / shoulder is frequently blocked, use mixed traffic criteria.
2. Qualifying bike lane / shoulder should extend at least 4 ft from a curb and at least 3.5 ft from a pavement edge or discontinuous gutter pan seam. Below this width, use mixed traffic cirtteria.
3. Bike lane width includes any marked buffer next to the bike lane.

[9] Reproduced from http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables-v2-June-1.pdf
[10] Standard methodology uses prevailing speed. Speed limits are used where prevailing speed data are not readily available. Where only *design* speed data are available, we will attempt to impute an estimate of prevailing speed or speed limits.
[11] Reproduced from: http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables-v2-June-1.pdf
[12] Standard methodology uses prevailing speed. Speed limits are used where prevailing speed data are not readily available, as in this case.

The presence of a bike lane without (**Table 2-2: Bike Lanes and Shoulders Not Adjacent to a Parking Lane**) or with (**Table 2-3: Bike Lanes Alongside a Parking Lane**) on-street parking allows higher combinations of speed and volume to achieve lower LTS levels. The actual methodology applied for Caltrans will depend on available data for segments and intersections in the State Highway System (SHS) and surrounding network.

Table 2-3: Bike Lanes Alongside a Parking Lane [13]

Number of lanes	Bike lane reach = Bike + Parking lane width	Speed Limit[14] ≤ 25 mph	30 mph	35 mph
1 lane per direction	15+ ft	LTS 1	LTS 2	LTS 3
	12-14 ft	LTS 2	LTS 2	LTS 3
2 lanes per direction (2-way)	15+ ft	LTS 2	LTS 3	LTS 3
2-3 lanes per direction (1-way)		LTS 2	LTS 3	LTS 3
other multilane		LTS 3	LTS 3	LTS 3

1. If bike lane is frequently blocked, use mixed traffic criteria.
2. Qualifying bike lane must have reach (bike lane width + parking lane width) ≥ 12 ft
3. Bike lane width includes any marked buffer next to the bike lane.

In addition to the segment scores, BLTS considers the stress associated with *crossings* of roads. Signalized intersections are not considered to increase stress; in these cases, the stress associated with the approach segments is used. For unsignalized crossings, stress is assessed according to Table 2-4: Level of Traffic Stress due to Unsignalized Intersection Crossings.

Table 2-4: Level of Traffic Stress due to Unsignalized Intersection Crossings[15]

	No Crossing Island			**Crossing Island**		
Speed limit/prevailing speed	**Up to 3 lanes**	**4 – 5 lanes**	**6+ lanes**	**Up to 3 lanes**	**4 – 5 lanes**	**6+ lanes**
Up to 25 mph	LTS 1	LTS 2	LTS 4	LTS 1	LTS 1	LTS 2
30 mph	LTS 1	LTS 2	LTS 4	LTS 1	LTS 2	LTS 3
35 mph	LTS 2	LTS 3	LTS 4	LTS 2	LTS 3	LTS 4
40+ mph	LTS 3	LTS 4	LTS 4	LTS 3	LTS 4	LTS 4

The original BLTS is primarily oriented at urban/suburban applications, where bikeways are more common. To supplement this approach, in rural areas (identified based on Traffic Accident Surveillance and Analysis System (TASAS) rural/urban field), we will consider the rural BLTS developed by Oregon DOT[16]. This method defaults to the standard BLTS for segments with posted speeds below 45 mph. For road segments posted at or above 45

[13] Reproduced from: http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables-v2-June-1.pdf
[14] Standard methodology uses prevailing speed. Speed limits are used where prevailing speed data are not readily available, as in this case.
[15] Reproduced from http://www.northeastern.edu/peter.furth/wp-content/uploads/2014/05/LTS-Tables1.pdf.
[16] https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx

mph, BLTS is assigned according to the values detailed in Table 2-5: Rural Segment LTS Criteria with posted speeds 45 mph or greater

Table 2-5: Rural Segment LTS Criteria with posted speeds 45 mph or greater

Daily Vehicle Volume (VPD)	Paved Shoulder Width		
	0-<2 ft.	2-<4 ft.	4+ ft.
< 400	LTS 2	LTS 2	LTS 2
400 – 1500	LTS 3	LTS 2	LTS 2
1500 – 7000	LTS 4	LTS 3	LTS 2
>7000	LTS 4	LTS 4	LTS 3

For intersections/crossings in rural environments, intersection approaches are considered to “gain” an LTS level if there are right/left turn lanes present. The intersection crossing itself in these cases is considered to be LTS 2 if the intersection is signalized, and follows the schema detailed in Table 2-6: Bicycle Level of Traffic Stress for Rural Crossings.

Table 2-6: Bicycle Level of Traffic Stress for Rural Crossings

Daily Volume (VPD)	<=3 lanes	4-5 lanes	>= 6 lanes
<400	LTS 2	N/A	N/A
400 – 1500	LTS 2	N/A	N/A
1500 - 7000	LTS 2	LTS 3	N/A
>7000	LTS 3	LTS 4	LTS 4

Limitations:

Network data quality:

Some of the necessary inputs will not be available statewide, such as speed limits, and bike lane widths. It would take effort beyond the scope of this project to consolidate all locally available data to create a comprehensive database. While a reasonable attempt will be made with each District to identify critical inputs, overall data quality limitations will be a constraint for this method.

Behavioral assumptions and individual variation:

Analysis parameters, such as threshold distances or BLTS classification, are based on evidence-based assumptions and averages. They will be accurate for many bicyclists, but it is impossible to understand the individual needs of every single bicyclist. Moreover, while BLTS is widely accepted as best-practice for bicycle planning, it is not a validated measure.

Pedestrian Level of Traffic Stress

To supplement the Bicycle LTS metrics, a pedestrian traffic stress measure can help to classify the pedestrian environment where sufficient data are available. Similar to the Rural Bicycle Level of Traffic Stress, Oregon DOT’s Analysis Procedures Manual presents a metric definition for Pedestrian Level of Traffic Stress (PLTS)[17], which will be followed here as well. The philosophy underlying the Pedestrian Level of Traffic Stress (PLTS) is generally

[17] https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx, Page 14-28

very similar to that behind BLTS. It classifies street segments and intersections based on the pedestrian experience, using a scale of 1-4 where a 1 corresponds to the lowest stress environment. Also similar to BLTS, PLTS is a “weakest link” measure, which means that the highest stress component of a given section of road governs the experience at that location. So, for example, if the lack of a significant buffer creates high-stress conditions despite a low-stress sidewalk being present, that segment would be rated as high-stress.

Unit of analysis: Sidewalks and crossings

Required Data Inputs: PLTS requires the following segment and crossing-level data. Segment data should be captured separately for both sides of the street, if possible.

Segments:

- Sidewalk condition and width
- Buffer type and width
- Bike lane width
- Parking lane width
- Number of lanes and posted speed
- Presence of illumination
- General land use description

Crossings (segment details are of road being crossed):

- Functional class
- Number of lanes and posted speed
- Presence of curb ramps
- Median refuge presence
- Illumination presence
- Signalization
- Presence of additional safety countermeasures (e.g., curb extensions, signage)

While all these details are required to complete the analysis, some of them are unlikely to be available district-wide. In these cases, assumptions will be made based on local conditions, as with the BLTS.

Desirable Additional Data Inputs: Average Daily Traffic is an optional detail that can be used to augment the crossing-level analysis.

What It Tells Us: PLTS describes the comfort level experience by pedestrians walking along a given road. It details multiple aspects of the pedestrian experience, including comfort associated with walking alongside traffic, stress due to crossing traffic, and comfort associated with navigating the environment for those with mobility impairments. As with BLTS, PLTS can be used as a succinct summary of infrastructure needs.

How It Is Calculated: There are four components of the PLTS measure: sidewalk condition, physical buffer, surrounding land use, and crossing experience (at intersections/midblock crossings). The first three of these correspond to segment scores and the last is focused on crossings. Each unit is analyzed on all of these underlying components, and the scores are then aggregated for the segment or crossing by taking the “worst” score present. The methodology as presented here follows exactly the methodology outlined in the ODOT Analysis Procedures Manual[18]. However, deviations can be incorporated at the district level as appropriate.

[18] https://www.oregon.gov/ODOT/Planning/Pages/APM.aspx, Page 14-28

The sidewalk condition criteria, as detailed in Table 2-7: PLTS Sidewalk Condition Criteria below, defines the stress associated with the presence and condition of a sidewalk. Excessively narrow sidewalks can create a stressful environment, especially when they do not meet accessibility requirements for minimum clear width. Likewise, sidewalks of poor quality can create difficult traveling conditions for those with mobility impairments or using assistive devices.

Table 2-7: PLTS Sidewalk Condition Criteria[19]

Actual/Effective Sidewalk Width (ft)[20]		**Sidewalk Condition**			
		Good	**Fair**	**Poor**	**No Sidewalk**
Actual	< 4	PLTS 4	PLTS 4	PLTS 4	PLTS 4
	>= 4 to <5	PLTS 3	PLTS 3	PLTS 4	PLTS 4
	>= 5	PLTS 2	PLTS 2	PLTS 3	PLTS 4
Effective	>= 6	PLTS 1	PLTS 1	PLTS 2	PLTS 4

While having a sufficiently wide and well-maintained sidewalk is important for the pedestrian environment, the presence of traffic alongside the sidewalk can create a stressful experience, particularly when traffic speeds are higher. The presence of physical buffers between the sidewalk and road can help to limit this effect, as can the provision of lateral separation between the traffic lanes and the sidewalk through parking lanes, bicycle lanes, and buffer zones. Table 2-8: PLTS Physical Buffer Type Criteria presents the PLTS levels for various traffic speeds and types of physical buffer. The presence of a physical buffer becomes more important at higher speeds. Landscaping, especially with vertical separation or trees, can be even more effective at reducing pedestrian stress than a simple solid surface buffer zone.

Table 2-8: PLTS Physical Buffer Type Criteria[21]

Physical Buffer Type				
Buffer Type	Prevailing or Posted Speed			
	<= 25 MPH	30 MPH	35 MPH	>= 40 MPH
No Buffer	PLTS 2	PTLS 3	PLTS 3	PLTS 4
Solid surface	PLTS 2	PLTS 2	PLTS 2	PLTS 2
Landscaped	PLTS 1	PLTS 2	PLTS 2	PLTS 2
Landscaped with trees or vertical separation	PLTS 1	PLTS 1	PLTS 1	PLTS 2

The lateral separation between the outside travel lane and the sidewalk can help to reduce the stress associated with walking along a road. The wider the road is (in terms of number of lanes), the more lateral separation is

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[19] Source: ODOT Analysis Procedures Manual, Exhibit 14-16
[20] "Effective width" refers to the usable sidewalk width.
[21] Source: ODOT Analysis Procedures Manual, Exhibit 14-17

needed to reduce the stress due to the street. Lateral buffering can be created through various means, including the buffer zone on the sidewalk, a parking lane or shoulder, and the presence of a bike lane.

Table 2-9: PLTS Total Buffer Width Criteria[22]

Number of Travel Lanes (both directions)	Total Buffering Width (ft), includes buffer, parking lane, shoulder, and bike lane width				
	< 5	>= 5 to <10	>= 10 to < 15	>= 15 to < 25	>= 25
2	PLTS 2	PLTS 2	PLTS 1	PLTS 1	PLTS 1
3	PLTS 3	PLTS 2	PLTS 2	PLTS 1	PLTS 1
4 – 5	PLTS 4	PLTS 3	PLTS 2	PLTS 1	PLTS 1
6+	PLTS 4	PLTS 4	PLTS 3	PLTS 2	PLTS 2

While the above features go a long way in characterizing the pedestrian environment along segments, land uses can provide additional insight into the level of stress associated with walking in a given location. Heavy industrial areas and freeway interchanges are typically high stress environments for pedestrians due to the extent to which heavy trucks are present, high traffic rates, and environments that are generally not designed with people walking in mind.

Table 2-10: PLTS Land Use Description Criteria[23]

PLTS	Land Use Classification
PLTS 1	Residential, central business district (CBD), neighborhood commercial, parks and other public facilities, government buildings/plazas, offices/office parks
PLTS 2	Low density development, rural subdivisions, unincorporated communities, strip commercial, mixed employment
PLTS 3	Light industrial, auto-oriented commercial
PLTS 4	Heavy industrial, intermodal facilities, freeway interchanges

In addition to the segment scores based on the above factors, crossings can be a major source of traffic stress for people walking. Crossing stress is assessed separately for signalized and unsignalized crossings. In general, any crossings where standard curb ramps are not available are automatically scored at PLTS 3 due to their impact on those with mobility impairments.

Signalized crossings, including HAWK beacons, are generally scored as PLTS 1. This gets downgraded to PLTS 2 if there are permissive turns across the crossing, a lack of lighting or countdown signal heads, and to PLTS 3 if any of a variety of complex elements are present such as a lack of standard ramps, more than six lanes being crossed, non-standard intersection geometry, and closed crosswalks.

Unsignalized crossings require greater consideration of the environmental conditions to assess pedestrian comfort, as these locations require judgments to be made by the crossing pedestrian.

Table 2-11: PLTS for Collector/Local Unsignalized Crossingspresents the PLTS for crossings of collector/local streets depending on the speed of the road being crossed, median refuge presence, and number of through

[22] Source: ODOT Analysis Procedures Manual, Exhibit 14-18
[23] Source: ODOT Analysis Procedures Manual, Exhibit 14-19

lanes. These scores only apply to crossings where 2 or fewer total lanes are being crossed, and where vehicle volumes are under 5,000 vehicles per day.

Table 2-11: PLTS for Collector/Local Unsignalized Crossings[24]

Prevailing Speed or Speed Limit (mph)	No Median Refuge		Median Refuge Present
	Total Lanes Crossed		Maximum One Through/Turn Lane Crossed per Direction
	1 Lane	2 Lanes	
<= 25	PLTS 1	PLTS 1	PLTS 1
30	PLTS 1	PLTS 2	PLTS 1
35	PLTS 2	PLTS 2	PLTS 2
>= 40	PLTS 3	PLTS 3	PLTS 3

For higher functional class roads, the PLTS scoring criterion again depend on the presence of median refuges, the number of lanes being crossed, vehicle volumes, and traffic speeds. Table 2-11: PLTS for Collector/Local Unsignalized Crossings details the scores for arterial crossings where no median refuge is present, and Table 2-12: Arterial Unsignalized Crossings with No Median Refuge pertains to locations with median refuges. To qualify as a pedestrian median refuge, the median must be at least 6' wide and include a raised concrete or vegetated island to qualify as a refuge, and at least 10' wide to qualify for a PLTS 1 rating.

Table 2-12: Arterial Unsignalized Crossings with No Median Refuge[25]

Prevailing Speed or Speed Limit (mph)	Total Lanes Crossed (Both Directions)					
	2 Lanes			3 Lanes		
	<5,000 vpd	5,000-9,000 vpd	>9,000 vpd	<8,000 vpd	8,000-12,000 vpd	>12,000 vpd
≤ 25	PLTS 2	PLTS 2	PLTS 3	PLTS 3	PLTS 3	PLTS 4
30	PLTS 2	PLTS 3	PLTS 3	PLTS 3	PLTS 3	PLTS 4
35	PLTS 3	PLTS 3	PLTS 4	PLTS 3	PLTS 4	PLTS 4
≥ 40	PLTS 3	PLTS 4	PLTS 4	PLTS 4	PLTS 4	PLTS 4

Note that for the ratings of arterial crossings with median refuges, the evaluation of number of lanes is based on the number of through/turn lanes per direction, whereas for those without a median the scores are based on the total number of lanes.

[24] Source: ODOT Analysis Procedures Manual, Exhibit 14-20.
[25] Source: ODOT Analysis Procedures Manual, Exhibit 14-21

Table 2-13: Arterial Unsignalized Crossings with No Median Refuge[26]

Prevailing Speed or Speed Limit (mph)	Maximum Through/Turn Lanes Crossed per Direction							
	1 Lane	2 Lanes			3 Lanes			4+ Lanes
	Any	<5,000 vpd	5,000-9,000 vpd	>9,000 vpd	<8,000 vpd	8,000-12,000 vpd	>12,000 vpd	Any
≤ 25	PLTS 1	PLTS 1	PLTS 2	PLTS 2	PLTS 1	PLTS 2	PLTS 3	PLTS 4
30	PLTS 2	PLTS 2	PLTS 2	PLTS 2	PLTS 2	PLTS 2	PLTS 3	PLTS 4
35	PLTS 2	PLTS 2	PLTS 2	PLTS 3	PLTS 3	PLTS 3	PLTS 4	PLTS 4
≥ 40	PLTS 3	PLTS 3	PLTS 3	PLTS 4	PLTS 4	PLTS 4	PLTS 4	PLTS 4

To account for the effects of crossing improvements, Table 2-14: PLTS Score Adjustments for Crossing Enhancementsdetails reductions to the PLTS that can be achieved by the addition of crossing improvements. Note that crosswalk markings and roadside signage adjustments do not apply when a median refuge is present, as these features are assumed in those cases. Additionally, note that these deductions are not additive; the maximum reduction due to crosswalk enhancements is 1 point.

Table 2-14: PLTS Score Adjustments for Crossing Enhancements

Treatment	Deduction	Treatment	Deduction
Markings	0.5	In-street signs	1.0
Roadside signage	0.5	Curb extensions	0.5
Lighting	0.5	Raised crosswalk	1.0
PAB	1.0		

Limitations: As an “expert-judgment” model, PLTS is not based entirely on tying conditions to outcomes. However, no such suitable planning-level measures exist, so PLTS represents the best-known measure for characterizing the built environment.

PLTS is also data input intensive. Accordingly, its application will depend on data availability and quality. While assumptions will be made as needed, ideally this measure would be calculated entirely based on observed data.

Barrier Permeability

Measure Description: Barrier permeability measures the extent to which a linear barrier (specifically, the state highways) require deviation from the shortest path to be crossed due to disruptions to the local street network. The barrier permeability metric requires a topologically valid (i.e., routable) local street network near the state highway. OpenStreetMap will be used for this analysis, given that it has a consistent format throughout the state and typically has high-quality topology.

Not all districts will require a barrier permeability analysis; this measure is not applicable to rural areas. Some Districts may elect to augment this analysis to focus on low stress routes which requires that LTS be calculated on the local streets. This may be completed in select districts provided sufficient local support to complete the

[26] Source: ODOT Analysis Procedures Manual, Exhibit 14-23 and 14-24

analysis. Alternatively, reasonable assumptions for stress-related variables can be made based on roadway functional classification.

What It Tells Us: This analysis tells us where segments of the SHS network may function as a barrier to pedestrian or bicyclist travel across the network.

How It Is Calculated: Barrier permeability is assessed purely as a network connectivity measure, which means that destinations are not explicitly considered. The following steps are followed in this process:

1. Identify sample points along the highway, e.g. every 250'.
2. (Optional) Select the subset of the local network to be used in analysis, e.g. the network can be restricted to only include low-stress freeway crossings.
3. At each sample point, create origin and destination points offset from the highway and snap them to the local street network. These points signify locations that somebody may want to cross the highway between.
4. Calculate the straight-line path and shortest network path between the origin and destination along the local street network.
5. Calculate a detour ratio for each origin-destination pair, calculated as the shortest path distance divided by the straight-line distance.
6. Use a sliding window to calculate average detour ratios along the highway.

An example application of this analysis on State Route 13 is presented in Figure 2-1. As can be seen, sections where crossing the highway requires substantial divergence from a straight-line path have worse scores from this metric.

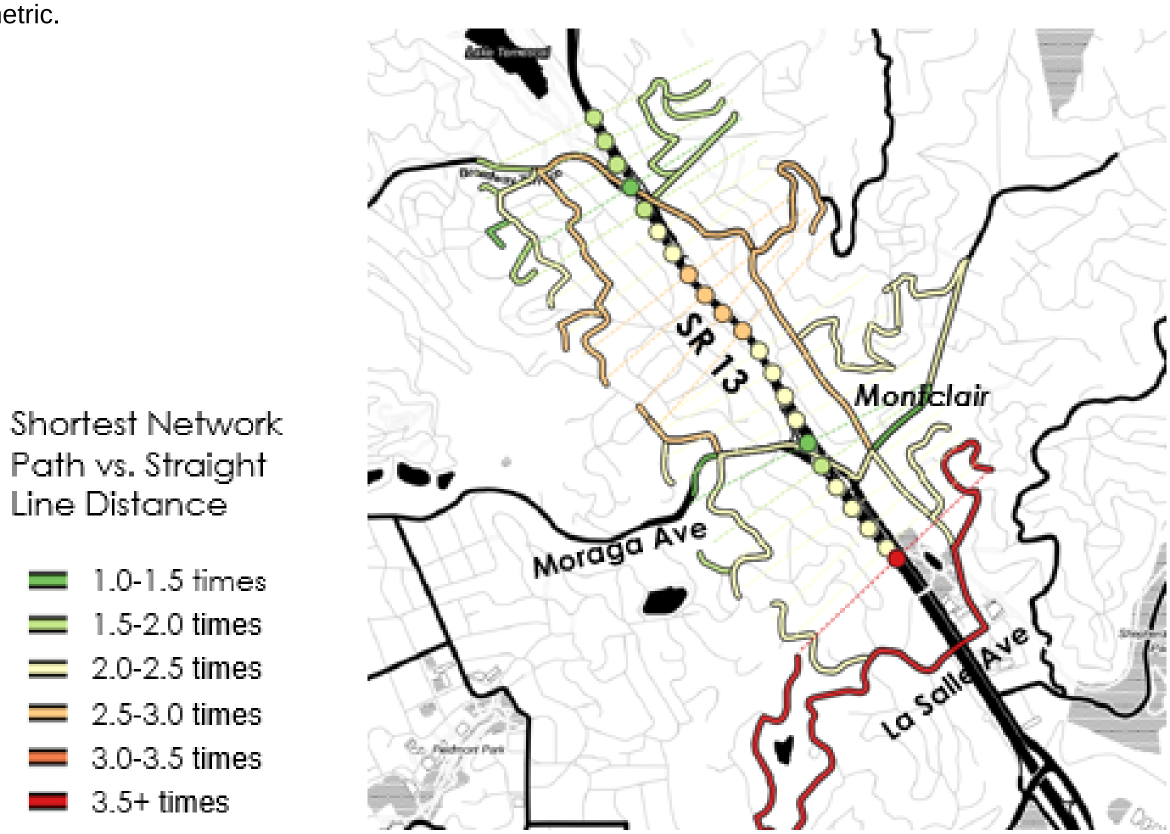

Figure 2-1: Example Application of Barrier Permeability Analysis

Limitations: Network data quality can limit the results of this analysis. It relies on the accuracy of network connectivity in the data, as that is how connections across the highway are identified.

GAPS AND BARRIERS

This section describes the particular types of gaps and barriers that will be identified based on the LTS and barrier permeability evaluations, as depicted in Figure 2-2. Location-Based Needs Identification Process. Once gaps and barriers are identified, needs will be suggested based on the context. Locations where an ongoing project exists serving bicycle and pedestrian traffic, such as through SHOPP, STPI, or HSIP, will not be considered as a need, as solutions are already planned in these cases. The preliminary needed actions, as described in Table 2-15. Location-Based Need Actions, will be refined based on projects identified from local plans when this data has been consolidated by District staff. Additionally, once needs have been prioritized in the weighted prioritization step, higher priority needs can also be re-evaluated and modified to reflect the most appropriate countermeasures based on District staff and consultant team judgment. District staff will also have the opportunity to add known needs based on their local knowledge and to refine the identified list of needs.

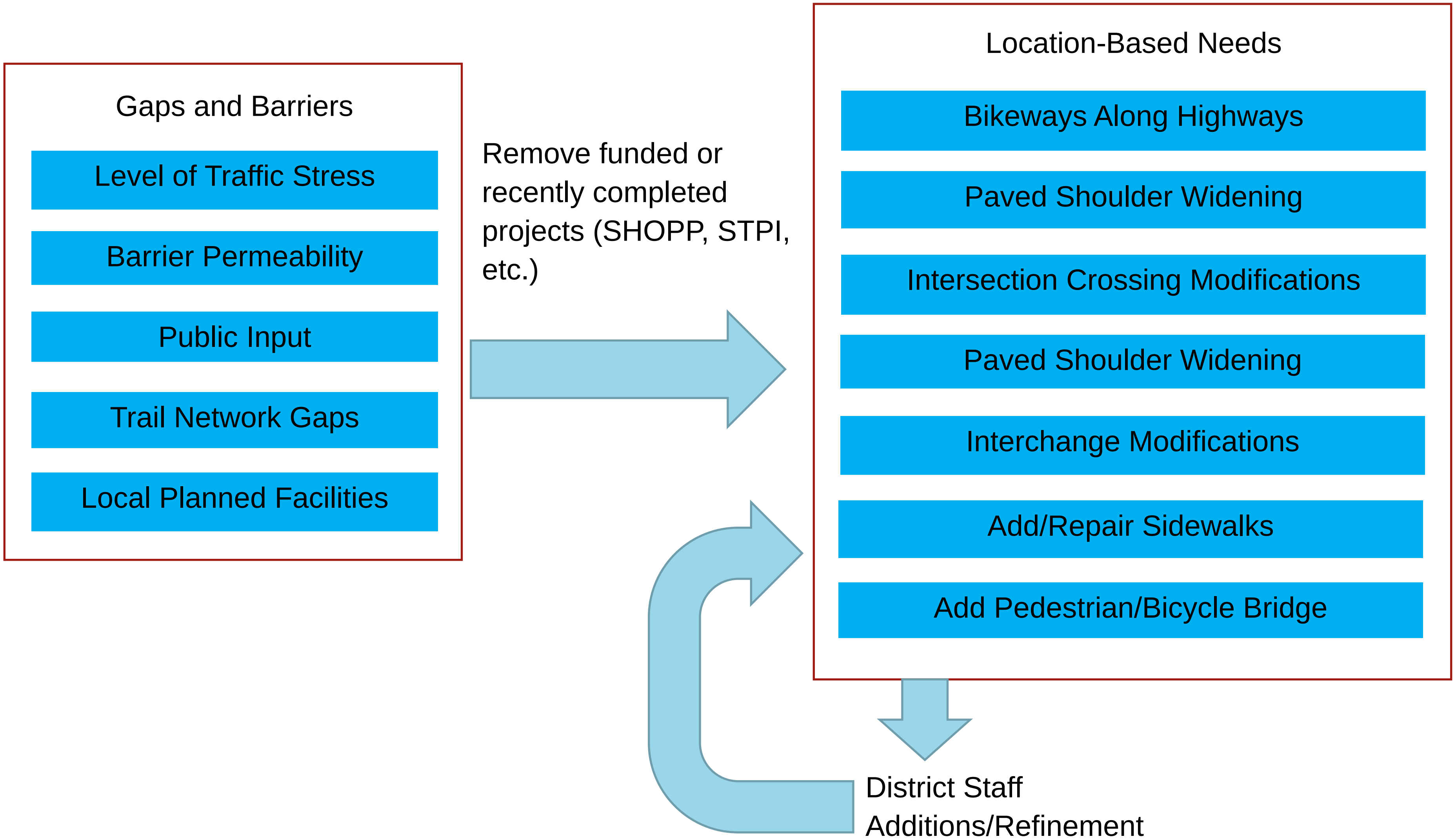

Figure 2-2. Location-Based Needs Identification Process

Mode	Existing Context	Action *	Notes
Bike	High Level of Traffic Stress Crossing	• Improve intersection for bikes.	
	High Level of Traffic Stress Corridor (Urban) High Level of Traffic Stress Corridor (Rural)	• Add bike facility. • Upgrade existing bike facility. • Add paved shoulder. • Widen exiting paved shoulder. • Identify parallel route. • Implement speed management.	Bike facility type determined by speed/volume thresholds; shoulder is default in rural area; speed management is where there is mismatch to roadway context (e.g. Main Street) and/or crashes
Pedestrian	Sidewalk Gap Along Pedestrian Route	• Improve existing sidewalk. • Add new sidewalk.	Default is that sidewalks are needed wherever pedestrians are allowed and that sidewalks in poor condition in ATAIP need to be improved
	High Pedestrian Level of Traffic Stress (Crossings)	• Add crosswalk. • Improve existing crosswalk. • Add bridge. • Improve interchange. • Add pedestrian crossing island.	
Freeway crossings	Low permeability freeway barriers	• Add pedestrian and bicycle over/underpass. • Retrofit interchange to be more pedestrian/bicycle-friendly.	
Shared Use Paths/Trails	Gap in the trail network	• Add shared-use path/trails.	Assumption is that local feedback will be needed for this recommendation

Table 2-15. Location-Based Need Actions

High Bicycle Level of Traffic Stress Crossing

Conventional highways can serve as both critical routes and important barriers for people bicycling in urban and rural environments. In both contexts, bicycle-supportive intersection modifications can help to reduce the stress associated with crossings. Signalization is the most effective such intervention, although other crossing improvements can also help to reduce stress.

High Bicycle Level of Traffic Stress along Urban Corridors

Urban highways can present stressful environments for people bicycling due to high traffic speeds and volumes and limited bicycle accommodations. In these environments, a variety of bikeway corridor treatments can be appropriate depending on context.

In addition to installing or upgrading a bikeway along the state highway, other options to provide low-stress accommodations can include managing traffic speeds to lower traffic stress or identifying suitable alternate routes requiring minimal out-of-direction travel.

High Bicycle Level of Traffic Stress along Rural Corridors

In rural environments, conventional state highways often serve a critical role as connectors between communities where alternate route options are not available. Paved shoulders serve as the primary bicycle facility in these areas. Common treatments to reduce stress can include adding or widening paved shoulders or providing a lateral buffer between the shoulder and general purpose travel lanes.

Facilities with Limited Crossing Opportunities

In urban, suburban and rural areas, much of the State Highway System consists of at-grade arterials. Crossings of arterial roadways can create gaps in the pedestrian network for numerous reasons. Crossing may be prohibited on some intersection legs, and even at locations where crossing the roadway is legal, crossing distances and signal cycles may be long and there may be conflicts with turning vehicles. For other stretches of urban arterials, there may be long stretches between signal-controlled intersections. Pedestrians may have to choose between crossing a six-lane highway at an uncontrolled crosswalk or traveling significantly out of direction to access a pedestrian signal.

Grade-separated highways present barriers for people traveling on all modes. However, the inconvenience is especially acute for people walking or riding bicycles, who are more sensitive than other travelers to the additional distance that infrequent crossings can necessitate. Streets that cross freeways are often over a half mile apart (or further) in urban areas and may be several miles apart in rural areas. Over- and undercrossing facilities that accommodate people walking and bicycling can lessen these distances, though they should feel safe and convenient and be easy for people to navigate.

At locations where people walking *do* have the opportunity to cross grade-separated highways, these crossings are usually at interchanges, where freeway ramps connect the local street network to the highway. Ramp crossings pose numerous challenges, including high travel speeds, angles, and lack of traffic control at crosswalks. Furthermore, crossing is often not permitted at some legs of interchanges, in order to maximize motor vehicle throughput. Sidewalks may be as narrow as 4 feet, because much of the right of way has been dedicated to travel lanes.

Freeway crossing barriers will be evaluated based on the barrier permeability measure discussed above, including consideration of low-stress freeway crossings.

Gap in the Trail Network

Gaps in the trail network in the vicinity of state highways are locations where small sections of trail could make a large difference in improving network connectivity by linking existing trail sections. There are no known comprehensive trail layers that can be used to analytically identify this type of gap, so we anticipate that these will be identified in collaboration with local agency partners and District staff.

CHAPTER 3
PERFORMANCE MEASURES

3. PERFORMANCE MEASURES

This chapters outlines and describes the performance measurement framework for the Caltrans Active Transportation (CAT) Plans. Specific measures are presented in terms of how they are calculated and how they can inform our understanding about needs for active travel on the Caltrans system. The framework used here follows the goals outlined in *Toward an Active California*, which also align with the goal areas of the California Transportation Plan 2040:

- **Safety**: Reduce the number, rate, and severity of bicycle and pedestrian-involved collisions
- **Social Equity:** Invest resources in communities that are most dependent on active transportation and transit
- **Mobility:** Increase walking and bicycling in California
- **Preservation:** Maintain a high-quality active transportation system

These measures will ultimately be used to prioritize location-based needs that can help to achieve these goals. Following FHWA's *Performance Based Planning and Programming Guidebook*, the term "Performance Measure" is used to refer both to measures that can be used to track progress over time, and to measures that can be used to compare locations and investment alternatives. The primary focus in this document is on the latter use of the term.

The following tables summarize the key measures to be used for prioritization of needs in this project. Table 3-1: Statewide Measures depicts the measures that will be applied on a statewide basis. These can all be calculated based on statewide datasets and will be calculated for all districts.

Table 3-1: Statewide Measures

Goal Area	Statewide Measure	Type	Data Source	Methodology
Mobility	Latent Demand (3 mile/1 mile)	Float	Statewide Travel Demand Model short-trip potential	Need intersect with latent demand score polygon
	Adjacency to major transit station	Binary	GIS transit station dataset	Need within distance of transit station dataset
Safety	Linear crash density	Float	SWITRS	Need intersect w/ sliding window results
Equity	CalEnviroScreen population risk score	Float	CalEnviroScreen Population Characteristics score [27]	Project intersect w/ population score polygon
	Percent Students Received Free and Reduced Lunch	Float	Department of Education	Project intersect w/ Census Tract summary
	Median Household Income (Quantile)	Float	Census	Project intersect w/ Census Tract summary
Preservation	Improvement of Existing Asset	Binary	ATAIP	Need comparison to ATAIP

[27] The CalEnviroScreen Population Characteristics score is the average Sensitive Populations and Socioeconomic Factors component for that census tract

Likewise, Table 3-2: District Performance Measure Options defines various measures that can be calculated at the District-level and incorporated into the need prioritization process.

Table 3-2: District Performance Measure Options

Goal Area	Optional District Measure	Type	Data Source
Mobility	Public / stakeholder input on demand	Float	District Plan Public Engagement
	Locally-determined short-trip demand	Float	E.g., Streetlight Data
	Existing bicycle & walk trips	Float	CSTDM
Safety	Weighted linear crash density	Float	SWITRS
	Public / stakeholder input on safety	Float	District Plan Public Engagement
Equity	Locally identified disadvantaged community	Binary	E.g., tracts that meet threshold for MPO-defined disadvantaged communities

Each of these measures is now discussed in greater detail, organized by goal area.

MOBILITY MEASURES

The statewide plan's mobility objective is to increase walking and bicycling in California. Measures in support of this objective are focused on both identifying locations where people are likely to walk or bicycle. Generally, to achieve the goal of increasing walking and bicycling, the focus for these measures will be on potential or "latent" demand.

Demand

Unit of analysis: Traffic-Analysis Zones (TAZs)

Required Data Inputs: Mode shares by TAZ, origin-destination trip count tables.

Desirable Additional Data Inputs: Total estimated trips by mode within each TAZ.

What it tells us: Demand metrics give us an estimate of how much travel currently is or potentially could be made by walking and bicycling. The metrics proposed here specifically yield the number of active transportation trips that are being made now, the universe of potential active transportation trips that could be made under improved conditions, and the change that could occur if conditions are improved**.**

How it is calculated: There are a variety of demand metrics proposed, each of which can be calculated based on travel demand model data such as the California Statewide Travel Demand Model (CSTDM). The various potential measures include:

- **Existing number of Active Transportation trips.** This is the total number of trips starting or ending in each TAZ, subdivided by mode.
- **Existing number of Active Transportation trips, local area average:** This is the distance-weighted average number of trips, by mode, for zones within one mile of the TAZ centroid. While the first measure is focused on the trips that originate or terminate within specific zones, this measure is intended to capture trips that may traverse the zone in question.

- **Potential demand, bike trips: # of trips less than 10 miles.** Calculated as number of all trips originating or ending at the TAZ whose length is less than 10 miles, weighted by distance based on observed trip-making rates from California Household Travel Survey.
- **Potential demand, walk trips: # of trips less than 1 mile.** Calculated as number of all trips originating or ending at the TAZ whose length is less than 1 mile, weighted by distance based on observed trip-making rates from California Household Travel Survey.
- **Latent demand, bike trips.** The difference between the potential demand for bike trips and the existing number of bike trips, per above measures.
- **Latent demand, walk trips.** The difference between the potential demand for walk trips and the existing number of walk trips originating/terminating in each TAZ, per above measures.

When using each of these measures for screening, we will normalize the estimates by the area of the TAZ to yield comparable results.

Limitations: These demand measures have been designed to accept a variety of source datasets, potentially including travel demand models like the CSTDM and third-party datasets like Streetlight Data. For the statewide screen, we will focus on the CSTDM, as it is known to be consistent across the state and therefore provides a fair basis for comparison. However, within each district there is the opportunity to bring in additional demand datasets to provide further local context.

Currently, the CSTDM provides mode share estimates by zone, and total trip estimates for all modes between specified origin-destination pairs. However, it does not provide mode-specific origin-destination tables so these measures do not rely on that level of detail. Travel demand models like the CSTDM are typically not well suited for assessing specific link-flow estimates for bicycling and walking, as the route choice behaviors for these modes can be substantially more complex than for people driving. Accordingly, we focus our attention on zonal summaries.

Third-party datasets like Streetlight Data are a relatively recent development, and questions remain over whether there are any biases at the statewide level. For instance, there could be differences in the quality of the estimates between urban and rural areas that have not been accounted for and for which validation data is not currently available.

Transit Proximity

Required Data Inputs: Assessing transit proximity requires data on transit stations, including attributes on the type of station, and transit lines.

Desirable Additional Data Inputs: To calculate based on network distance, requires a topologically valid network dataset.

What it tells us: Whether a given location is proximate to transit stations.

How it is calculated: Proximity (straight line or network distance) of the segment in question to the nearest transit stop. Can be calculated separately for stations of different frequency or significance. For example, fixed route stations within ½ mi. may be relevant when bus stops may only be relevant within 1/10 mi.

Limitations: Does not account for network conditions.

Public Input

In addition to using previously developed data, some districts may choose to account for demand for walking and bicycling using public input. This approach will vary by district but can help to fill gaps in the understanding of demand based on the CSTDM. Possible questions to ask in a crowdsourcing map could include:

- Where do you currently bicycle on the state highway system for recreation?
- Where would you like to walk or bicycle on the state highway system if there were better accommodations?
- Where do you most frequently bicycle or walk on or across the state highway system currently?

Questions of this nature will produce point values, the density of which can be used as a prioritization criterion.

EQUITY MEASURES

Statewide Equity Indicators

At the statewide level, disadvantaged communities will be identified according to the criteria identified in *Toward an Active California*.

Required Data Inputs:

- Census demographics at the tract level.
- Number of students receiving free and reduce school lunches (Department of Education Student Poverty Database).

What it tells us: Equity measures tell us where disadvantaged populations live. As the focus of this planning effort is on equity, locations with higher concentrations of disadvantaged communities will be an important consideration in the needs prioritization process.

How it is calculated: The proposed equity measures summarize target populations who may be at a socioeconomic disadvantage. The following measures will be applied in the statewide process and considered in all Districts:

- Number of students receiving free or reduced-price school lunches.
- Number of low-income households.
- CalEnviroScreen ranking.[28]

Each indicator will be evaluated at the District-level to account for the differences in context across Districts. Additionally, each District has the option to consider MPO/RTPA-defined disadvantaged communities as “local disadvantaged communities.”

Limitations: Socioeconomic disadvantage can take many forms that show up in a variety of indicators. Refining this understanding at the District level to reflect local conditions will be critical to identifying target populations.

Additionally, equity considerations must be considered beyond the data-driven process defined in this report, especially in the process of public outreach. Disadvantaged communities are not monolithic in their needs or priorities, so effectively engaging stakeholders and performing targeted outreach with communities who may not attend a typical planning meeting will be imperative to fully accounting for equity in the needs identification process.

[28] https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

SAFETY MEASURES

Crash Density/Weighted Crash Density

Required Data Inputs: Pedestrian/bicycle crash records are needed to calculate this measure. Crashes need to be geocoded and should have crash severities if a weighted measure will be used.

What it tells us: Crash density tells us where there has been a history of crashes. When severity-weighted, it can tell us where there either have been particularly severe crashes, or a major preponderance of lower severity crashes. Locations with so many low severity crashes as to be comparable with locations with few high severity crashes can also be a concern, as the difference between crash severities for bicycle and pedestrian crashes can come down to individual-level characteristics such as the age of the pedestrian. Many low-severity crashes can be an indicator of a location that would warrant a safety countermeasure as well.

How it is calculated: Crash densities are calculated in incremental, overlapping segments along predefined routes on the network. This is a hotspot identification method.

The detailed calculation steps are as follows:

1. Dissolve all corridors based on the identified “route” field, which produces corridor geometries.
2. Using a pre-defined window size (1/2 mile) and step size (e.g. 0.1 mile), generate overlapping window segments based on the corridors.
3. Join crashes to the window segments. Crashes are associated with all window segments with which they intersect or are within a specified snapping distance of, i.e. they can be associated with multiple windows.
4. Aggregate crashes, by severity and mode, within each window segment.
5. (Optional) Calculate a “weighted” total of crashes for each window segment, weighting based on severity. A common weighting scheme is the Equivalent Property Damage Only metric (EPDO), which assess crash impact based on the expected costs associated with the crash according to severity, normalized to the expected cost of a Property Damage Only (PDO) crash.
6. For each distinct section of road, calculate the highest observed value for crash frequency or weighted crash total.

Limitations:

Screening for crash history does not account for the effects of “exposure,” or the number of opportunities for a crash to occur. Locations with a history of crashes either could indicate moderate risks to any individual traveler and high rates of exposure or could alternately indicate high risks with low-moderate exposure. Without this detail, it is difficult to assess which of these factors is at play.

Pedestrian and bicycle crashes are relatively rare at any given location, due in part to relatively low exposure rates, and therefore are highly susceptible to the “regression to the mean” phenomenon. That is, two otherwise identical locations might only be different in that one observed a crash and the other did not due to chance alone. However, even though one of the locations experienced a crash, if the two locations truly are otherwise identical, they should be prioritized similarly based on safety[29].

Pedestrian and bicycle crashes are known to be underreported at a high rate in police databases.

[29] https://safety.fhwa.dot.gov/hsip/resources/fhwasa09029/sec2.cfm

Public Input

In addition to using crash data, some districts may choose to account for safety for walking and bicycling using public input. This approach will vary by district but can help to fill gaps based on the experience of the public. This measure would likely come about from asking a single question of members of the public, such as "What locations on the state highway network do you see as dangerous for people walking or bicycling?"

A question of this nature will produce point values, the density of which can be used as a prioritization criterion.

PRESERVATION MEASURES

Improvement of Existing Asset Condition

Required Data Inputs: Calculating this measure requires an understanding of the existing location and condition of assets.

What it tells us: This measure tells us whether a given need would improve the state of good repair for the system.

How it is calculated: For any identified needs, this is simply a binary indicator for whether the need is to improve the condition of an existing asset, such as by fixing pavement quality or replacing worn hardware.

Limitations: There is generally limited data on the quality of existing bicycle and pedestrian assets, which leaves little baseline for comparison on this measure.

In some locations on the system, the lack of any facility for active transportation is a larger concern than the existing condition of infrastructure, so care should be taken with this measure to not distract from the pressing concerns of missing infrastructure.

Conclusions

Some of the performance metrics detailed in this chapter will be used to prioritize location-based needs on the State Highway System in each Caltrans District. Not every metric defined here will be considered in every District, but this instead represents the spectrum of options available. Additionally, for some of these metrics, some Districts may choose to rely strictly on the statewide metric definitions, while others may choose to alter how the measures are calculated to suit their local conditions. Districts may also add additional measures that are deemed to be important for prioritization locally.

All of the measures defined here depend on the quality of the data underlying them. Accordingly, not all metrics can be calculated in every District or on every route, as some datasets are not comprehensively available across the entire system. Where necessary, we will make and clearly document reasonable assumptions within each District screening process to be able to calculate metrics.

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CHAPTER 4
PRIORITIZATION PROCESS

4. PRIORITIZATION PROCESS

This chapter outlines and describes the proposed framework for prioritizing district-weighted, location-based active transportation needs in Caltrans Active Transportation (CAT) Plans. The proposed framework addresses the goals outlined in ***Toward an Active California** (2017)*, the statewide bicycle and pedestrian plan:

- **Safety:** Reduce the number, rate, and severity of bicycle and pedestrian-involved collisions.
- **Social Equity:** Invest resources in communities that are most dependent on active transportation and transit.
- **Mobility:** Increase walking and bicycling in California.
- **Preservation:** Maintain a high-quality active transportation system.

APPROACH

The methodology for calculating District-weighted, location-based active transportation needs follows the following four steps, which are described in subsequent sections (*responsible party in parentheses*):

1. **Select Prioritization Metrics:** In addition to a required base set of statewide prioritization metrics, Districts may choose optional Mobility, Safety, Equity, and Preservation metrics to include in the prioritization process. *(Caltrans District Office, Stakeholders)*

2. **Calculate Goal Scores**: Generate scores for each prioritization metric and calculate normalized goal scores. *(Consultant team)*

3. **Weight District Goals**: Assign local weighting for Mobility, Safety, Equity, and Preservation goals according to District preferences. (*Caltrans District Office, Stakeholders*)

4. **Identify Prioritized List of Location-Based Needs**: Apply weighting to goal scores to produce highest, high, medium, and low priority location-based needs. *(Consultant team)*

Step 1. Select Prioritization Metrics

The goals from *Toward an Active California* are intended to guide the prioritization of location-based needs. A layered approach is employed to highlight the areas with the most pressing needs in each district. For example, a corridor that has a high pedestrian and bicycle crash history, significant existing walking and bicycling demand, high opportunity to capture more short trips, and a relatively large percentage of low-income households is a higher priority than a corridor that has none of these characteristics. Similarly, a rural highway that serves as a Main Street or that connects two small towns in close proximity is a higher priority than one that is likely to have less demand for walking and biking.

The first step in the process is to select from a menu of available prioritization metrics. Table 4-1: Statewide Location-Based Needs Prioritization Criteria presents a summary of prioritization criteria to be included in every District prioritization process.

Table 4-1: Statewide Location-Based Needs Prioritization Criteria

Goal Area	Statewide Measure	Type	Data Source	GIS Methodology
Mobility	Latent Demand	Float	Statewide Travel Demand Model short-trip potential	Intersect
	Adjacency to major transit station	Binary	GIS transit station dataset	Buffer
Safety	Linear crash density	Float	SWITRS	Intersect
Equity	CalEnviroScreen score	Float	OEHHA CalEnviroScreen 3.0	intersect
	Median Household Income (MHI)	Float	US Census ACS	intersect
Preservation	Improvement of Existing Asset	Binary	ATAIP	intersect

Statewide datasets will provide a consistent baseline for the initial prioritization; however, District-specific datasets and locally selected measures can be incorporated to reflect local context. Examples could include Districts that have robust pedestrian and bicyclist count data programs or that have data on operating speed of vehicles rather than just the posted speed. The systemic needs identification in the previous step positions Caltrans to react and respond to opportunities that arise, for example an upcoming corridor project that could potentially add features that will reduce the Level of Traffic Stress for people walking and biking. The initial prioritization of needs begins to position Caltrans to address priority locations in a more proactive way, for example to program countermeasures where clusters of crashes are occurring, which are specifically selected based on the characteristics of the crashes.

In addition to these statewide measures, Districts may consider optional district criteria, such as those indicated in Table 4-2: Optional District Location-Based Needs Prioritization Criteria. District and stakeholder feedback can also be incorporated into the needs prioritization process, for example by allowing the public to indicate which of the identified needs are the most important to them.

Table 4-2: Optional District Location-Based Needs Prioritization Criteria

Goal Area	Optional District Measure	Data Source
Mobility	Public / stakeholder input on demand	District Plan Public Engagement
	Locally-determined short-trip demand	E.g., Streetlight Data
	Existing bicycle & walk trips	Local bicycle/pedestrian count programs; Streetlight Data, CSTDM
Safety	Weighted crash density	SWITRS
	Public / stakeholder input on safety	District Plan Public Engagement
Equity	Locally identified disadvantaged community	E.g., tracts that meet threshold for MPO-defined disadvantaged communities
	Free or Reduced Priced School Meals[30]	California Department of Education

Step 2. Calculate Goal Scores

There are three steps to calculating Mobility, Safety, Equity and Preservation Goal scores.

1. **Calculate raw metric scores.** Once metrics have been selected, the consultant team will utilize the statewide data framework to calculate individual metric scores for statewide metrics and any District additions. The previous chapter describes the approach for calculating individual metric raw scores.
2. **Normalize metric scores.** Next, raw metric scores must be normalized on a 0.0 – 1.0 scale for comparison purposes, where 0.0 represents lowest need, and 1.0 represents highest need. All metric scores will be normalized at the District-level to accurately capture District needs. There are two types of metrics in the statewide criteria listed in the table on the previous page. Table 1:
    a. *Binary metrics* indicate the presence or lack of a specific need, and will be normalized as follows:
        i. Null: 0.0
        ii. Positive: 1.0.
    b. *Float metrics* are scored a fractional value between 0 (lowest value) and 1 (highest value), based on percentile level of need compared to the rest of the District. For example, a five-tier percentile system would be scored as follows:
        i. 0-20th percentile: 0.0
        ii. 20th-40th percentile: 0.25
        iii. 40th-60th percentile: 0.50
        iv. 60th-80th percentile: 0.75
        v. 80th-100th percentile: 1.0
3. **Calculate goal scores**. Once metrics are normalized, the project team will calculate total goal scores by averaging metric scores within each goal. For an example, if Mobility Metric A scores 0.0, and Mobility Metric B scores 0.5, the total Mobility score will be 0.25.
4. **District staff screening.** All preliminary project scoring should be screened by District staff prior to weighting to verify analytics and to ensure they are consistent with expectations.

Step 3. Weight District Goals

Next, Districts apply a weight to each of the four Goal Areas. Weighting the goals allows Caltrans to respond to policy and leadership priorities, for example to demonstrate and quantify how equity is elevating specific projects over others. A statewide baseline weighting will be provided, which aligns with the current weighting used in the

[30] ATP Metric. Qualified as disadvantaged area if at least 75% of local public school students are eligible to receive FRPM. Note that in for ATP purposes, this metric only applies to Safe Routes to School projects.

Active Transportation Program; however, Districts will also have the ability to adjust their weighting to account for local priorities. This will be accomplished by allowing Districts to scale up or down the weighting of specific goals within a predefined range.

The first step in the evaluation of location-based needs is to establish local weights for each of the four active transportation goals. Figure 4-1: Sample Goal Weighting presents a sample goal weighting scheme.

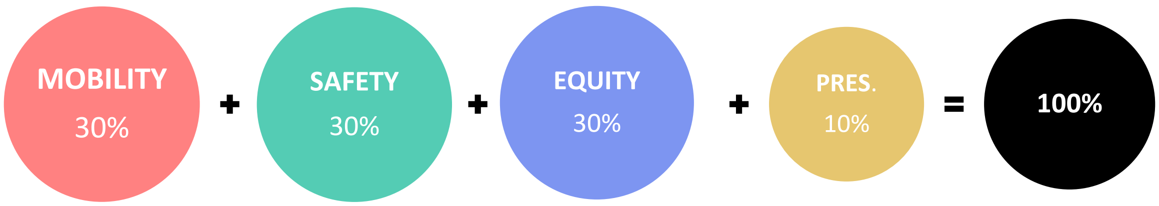

Figure 4-1: Sample Goal Weighting

This decision should reflect the direction of District staff, and the input of District stakeholders.

Step 4. Rank Cumulative Location-Based Need

Once metric scores are normalized, combined into goal scores, and weighted, they can be combined to produce a District-specific ranking of High, Medium, or Low need. This simple ranking system will be based on a percentile comparison to other cumulative District scores, as follows:

- **Calculate raw cumulative need**. The consultant team will apply the goal weights identified in Step 3 to each goal score and sum them cumulative location-based need scores for each zone. For example:

Mobility		Safety		Equity		Preservation	
(1.0 * 30%)	+	(0.5 * 30%)	+	(0.5 * 30%)	+	(0.0 * 10%)	= **0.6**

- Rank needs. The consultant team will then assign priority to each location-based need scores on a percentile basis. For example:

Highest Need: 75th-100th percentile

High Need: 50th-75th

Medium Need: 25th-50th

Low Need: 0-25th

Districts will be given the opportunity to adjust these break points to match their local needs.

The result of this prioritization process will be a geospatially referenced list of needed bicycle and pedestrian-related infrastructure, categorized based on the level of need. District staff will be able to use this list, in coordination with local agency partners, as a starting point for developing active transportation-specific projects and for incorporating these needs into other projects as they are developed.

CONCLUSION

The Caltrans Active Transportation data framework will inform decision-making and improve outcomes, positioning Caltrans to pursue active transportation improvements from both a reactive and a proactive perspective. The results of the analysis process will be generated and displayed with the purpose of feeding directly into the project development and asset management process to, over time, ensure that active transportation needs can compete on equal footing with the needs of other modes. This will help to achieve the vision and operationalize the goals established in *Toward an Active California*.

At this stage, we are currently deploying the framework in two prototype plans. Any lessons learned during the course of these prototype planning processes may be incorporated into the final version of this document, and it will be used to guide the remaining work of developing plans for the remaining ten district plans.