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Performance Measures for Complete, Green Streets: A Proposal for Urban Arterials in California

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PERFORMANCE MEASURES FOR COMPLETE, GREEN STREETS:
A PROPOSAL FOR URBAN ARTERIALS IN CALIFORNIA

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EXECUTIVE SUMMARY

The California Department of Transportation (Caltrans) manages over 15,000 miles of state highways, which range in scale and function from local streets to interstate highways. Historically, the work of Caltrans has been governed by the principles of highway engineering, which focus on providing mobility to motorized vehicles. Over the past decade, however, the Agency has joined in a national movement to better incorporate non-motorized transportation and community-level outcomes, such as walkability and cleaner air, into its transportation decision-making framework. One example of this shift occurred in 2008, when Caltrans issued *Deputy Directive 64-R1: Complete Streets – Integrating the Transportation System*. DD-64-R1 mandates the provision of bicycling and walking facilities along Caltrans' roadways (except where prohibited), thus creating Complete Streets, which are defined as "transportation facilit(ies) that (are) planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit riders, and motorists appropriate to the function and context of the facility."[1] Through DD-64-R1, Caltrans acknowledges that Complete Streets have the potential to benefit the State in several ways: improved safety and convenience for people who walk, bicycle, or use transit; increased health for people who choose active transportation modes; reduced traffic congestion and auto-related air pollution; and long-term fiscal savings.

In conjunction with the movement to build Complete Streets, there is also an effort in California and nationwide to mitigate the negative impacts that road projects can impose on surrounding communities. Negative environmental effects may result directly from the transportation facility, for example, when an increase in paved surface area leads to reduced absorption of stormwater or increased local air temperature through the urban heat island effect. Harmful environmental consequences also derive from the associated vehicle pollutants and emissions that are released into the air and groundwater. In addition to reducing the community quality along the roadway, these externalities contribute to regional problems like watershed damage and international concerns like global climate change. One approach that some cities and state agencies are taking to offset these negative impacts is to build Green Streets. Green Streets are

[1] Caltrans (2008) *Complete Streets—Integrating the Transportation System, Deputy Directive 64-R1 C.F.R.*

defined as streets that maximize permeable surfaces, tree canopy and landscaping elements in order to divert stormwater from the sewer system; filter and reduce the amount of polluted stormwater entering rivers and streams; increase urban greenspace; improve air quality and reduce ambient air temperature; and improve watershed health.[2] There is some evidence that Green Streets also improve pedestrian and bicycle safety and promote travel by these modes.[3]

Caltrans has a tremendous opportunity to become a leader in incorporating Complete and Green Streets principles into state-level transportation planning. However, there still exist a range of internal, administrative barriers that will make it difficult for Caltrans to broadly apply a more holistic approach to transportation decision-making. This research endeavor addresses some of these barriers by providing Caltrans with new performance measures that would broaden and enhance the Agency's adopted set of goals and objectives. Caltrans currently publishes quarterly reports that track progress toward goals in five key areas: Safety, Mobility, Delivery, Stewardship and Service. Caltrans' current set of objectives and performance measures, however, represent the historical, auto-oriented focus of the Agency; there are no measures that specifically address non-motorized transportation, and minimal consideration is given to environmental impacts caused by state transportation facilities. For these reasons, the existing framework is incompatible with the deputy directive on Complete Streets (DD-64-R1) and does not recognize the important role that Caltrans could play in achieving state and national goals regarding environmental and community health.

In order to ensure that Caltrans is designing and building Complete, Green Streets, the agency needs a more robust system of performance measures including new measures for environmental stewardship and non-motorized safety and mobility. Recognizing this need, Caltrans initiated this project and through the University of California Transportation Center at Berkeley supported research into the effects of transportation corridor design features on user behavior and safety, the environment, public health, and community economic vitality, as well as the creation of defensible performance measures derived from the research that could be used by the agency.

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[2] City of Portland, *Portland Green Streets Policy*. Retrieved June 10, 2009 from: http://www.portlandonline.com/BES/index.cfm?c=44407

[3] ibid., 3

The result of these research efforts is a *Complete, Green Streets Performance Measures Framework for Urban Arterials.*

Project Overview and Scope of the Research Effort

This research project was divided into two phases: a comprehensive Literature Review and the development of performance measures. For the literature review, the research team cast a wide net to find and examine studies dealing with the effects of transportation corridor design features on user safety; walkability, bikability, and physical health; psychological well-being; community and economic vitality; and varying environmental concerns. Approximately 165 studies and reports were reviewed, including articles published in leading industry journals, studies conducted by various university research centers, dissertation studies, and research undertaken by government agencies at all levels.[4] *Due to directives from Caltrans, plus funding and time constraints, the scope of the literature review was limited to corridor roadside design features and other design elements that contribute to traffic calming, walkability, and bikability, such as travel lane widths, crosswalks, and bicycle lanes. Transit and larger issues of land use were not addressed.*

After completion of the Literature Review, the research team turned its attention to the development of performance measures. To gain understanding of the best thinking regarding performance measurement, the team reviewed dozens of studies and reports concerning both the theoretical aspects of the development and operation of performance measures, and the specific issues related to their use in transportation planning. The researchers also reviewed the performance measurement systems used by state DOTs around the country to identify best practices related to Complete Streets and Green Streets concepts—concepts that were found to mesh well with the findings from the Literature Review—in addition to Caltrans' own use of performance measures. This cumulative research plus the findings of the Literature Review served as the basis for determining which corridor design elements the proposed performance measures would focus on, how the measures would be formulated, and how the measures would be presented. *Following the focus of the Literature Review, the performance measures focus primarily on roadside design elements and do not address transit or land use.*

[4] For a list of all literature reviewed, see Appendix B.

As well, the performance measure framework is directed toward *urban arterials*, rather than all Caltrans highways, because research and observation suggests these are the highways on which the greatest conflicts between motorized and non-motorized traffic occur, and where local quality of life is most severely impacted by design of the highway facility.

The Complete, Green Streets Performance Measure Framework

The structure and format used to present the proposed performance measure framework is based on Caltrans' current performance measurement system, because this approach was deemed to offer the greatest likelihood that the Agency would adopt the new framework. For example, each proposed objective fits within one of the Agency's five goal areas, and is followed by one or more performance measures that will allow the agency to monitor progress toward that objective.

The objectives and corresponding performance measures from the proposed *Complete, Green Streets Performance Measure Framework for Urban Arterials* are listed below. In several places, an "X" is used as a placeholder for a year or target where more work is needed before a finite target year (i.e. 2017) or target level (reduce injury rate to 1 per 1 million vehicle miles traveled) can be set. Where dates are set, they are based on Caltrans' current practice of using 5-year increments coinciding with their Strategic Plans. For the full discussion of how and why the objectives and measures were developed, refer to Chapter V.

Safety

CALTRANS SAFETY GOAL: Provide the safest transportation system in the nation for users and workers.

Proposed Complete Green Streets (CGS) Objective 1.1: By 2012, reduce the annual pedestrian and bicycle injury and fatality rates to the following levels, and continuously reduce annually thereafter with the goal of having the lowest rates in the nation. *Targets:* Pedestrian fatality rate: X per X walking trips; Pedestrian injury rate: X per X walking trips; Bicyclist fatality rate: X per X bicycling trips; Bicyclist injury rate: X per X bicycling trips.

- PM 1.1a: Rate of pedestrian fatalities per walking trips.
- PM 1.1b: Rate of pedestrian injuries per walking trips.
- PM 1.1c: Rate of bicyclist fatalities per bicycling trips.
- PM 1.1d: Rate of bicyclist injuries per bicycling trips.

Proposed CGS Objective 1.2*:* By 2017, double the percentage of people who feel safe using non-motorized modes on urban arterials. By 2022, increase this percentage to XX%.

- PM 1.2: Percentage of Californians who feel safe using non-motorized modes on urban arterials.

Proposed CGS Objective 1.3: By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase safety for non-motorized users in accordance with Complete Streets principles. By 20XX, all Caltrans urban arterials are designed for safety according to these principles.

- PM 1.3a: Percent of signalized intersections along 2- or 3-lane arterials with marked crosswalks and one or more of the following: countdown signals, leading pedestrian intervals, bulb-outs, or pedestrian refuge islands.
- PM 1.3b: Percent of unsignalized 4-way (multilane) intersections along urban arterials with marked crosswalks and one or more of the following: HAWK signal[*], yield to pedestrian signage, user-activated overhead warning lights.
- PM 1.3c: Percent of urban arterial intersections with one or more of the following improvements geared toward bicyclists: bike box[*], painted bicycle lane through the intersection[*], bicycle signal, functioning bicycle loop detectors, bicycle left turn lane.
- PM 1.3d: Percent of urban arterials on which the 85th percentile driving speed is no greater than 25 mph.

[*] It should be noted that the HAWK signals have not yet been approved for use in California, although it is expected to be so in the future. Bike boxes and painted bicycle lanes have been approved for provisional use.

Proposed CGS Objective 1.4: By 2012, annually reduce the number of pedestrian and bicycle hotspots (high collision concentrations) on urban arterials.

- PM 1.4a: Overall number of pedestrian collision hotspots on urban arterials.
- PM 1.4b: Overall number of bicycle collision hotspots on urban arterials.

Mobility

CALTRANS MOBILITY GOAL: Maximize transportation system performance and accessibility.

Proposed CGS Objective 2.1: By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase mobility for non-motorized users in accordance with Complete Streets principles, aiming to link up to a larger community bicycle and pedestrian network where possible. By 20XX, *all* Caltrans urban arterials are designed for non-motorized mobility according to these principles.

- PM 2.1a: On urban arterials, ratio of sidewalk mileage to roadway mileage, bi-directionally.
- PM 2.1b: On urban arterials, ratio of Class II bicycle facility mileage to roadway mileage, bi-directionally.
- PM 2.1c: On urban arterials, percentage of intersections that are ADA compliant.
- PM 2.1d: Percentage of urban arterial projects designed as Complete Streets.
- PM 2.1e: Number of pedestrian trips on urban arterials.
- PM 2.1f: Number of bicycle trips on urban arterials.

Delivery

CALTRANS DELIVERY GOAL: Effectively deliver quality transportation projects and services.

(No new proposed Delivery objectives)

Stewardship

CALTRANS STEWARDSHIP GOAL: Preserve and enhance California's resources and assets.

Proposed CGS Objective 4.1: Annually increase the total mileage of urban arterials designed to minimize negative environmental impacts in accordance with Green Streets principles. By 20XX, *all* urban arterials are designed as Green Streets.

- PM 4.1a: Ratio of pervious to impervious surfaces on Caltrans urban arterials, including medians, buffer strips, and planter holes.
- PM 4.1b: Percent of urban arterial lane mileage with tree canopy coverage.

Proposed CGS Objective 4.2: By 20XX, all Caltrans urban arterials meet a baseline for non-motorized facility quality.

- PM 4.2a: Percent of urban arterial sidewalk mileage in fair or better condition.
- PM 4.2b: Percent of urban arterial bicycle lane mileage in fair or better condition.

Service

CALTRANS SERVICE GOAL: Promote quality service through an excellent workforce.

Proposed CGS Objective 5.1*:* Annually increase the number of Caltrans management, design, and maintenance personnel trained regarding Complete Streets principles and Green Streets principles, with the goal of 100% trained.

- PM 5.1a: Number of personnel trained in Complete Streets principles.
- PM 5.1b: Number of personnel trained in Green Streets principles.

Moving Forward

There are several steps that Caltrans needs to take in order to incorporate these proposed *Complete, Green Streets Performance Measures* into their existing framework. Most importantly, new data must be collected and existing procedures for recording data must be

adjusted to isolate pedestrian and bicyclist trips and safety, urban arterial design features, and staff trainings related to Complete Streets and Green Streets. While it is certain that collecting new data will be both costly and administratively intensive, it will be a fundamental step in Caltrans' effort to provide a more multimodal and community-serving transportation system.

INTRODUCTION

Overview

California's transportation corridors must meet many needs. They serve multiple travel modes – motorized (cars, trucks, and transit vehicles) and non-motorized (pedestrians and bicyclists), and local, regional, and interregional traffic. They are a central feature in many urban and suburban neighborhoods and rural communities. In the past, transportation corridors have been designed primarily to maximize the throughput of motorized vehicle traffic. Recently, however, members of local communities have begun to question the wisdom of this approach, and have begun to push for transportation corridors that are designed to meet local needs as well as throughput needs, and that safely accommodate multiple travel modes. These efforts are supported by an increasing focus among city planners, designers, transportation engineers, and public health practitioners on enhancing the quality of life within communities. Local community quality of life is adversely affected by the presence of high volumes of motorized traffic moving much faster than pedestrians and bicyclists and thus diminishing roadway safety; increasing levels of obesity that may be related to community design characteristics that diminish walkability and bikability and hence contribute to reduced levels of physical activity; increases in air and water pollution levels due to automobile and truck throughput; and a growing population of aging baby boomers who may lose their mobility if options other than driving alone are not provided.[5]

The design of transportation corridors communicates many things to its users, and the message it sends can affect the travel mode a user decides to take, the speed at which a motorist decides to drive, whether a pedestrian will walk along or across a street, and whether a resident will bicycle to local shops. Design elements give visual cues to the users of transportation corridors that let them know what needs have been prioritized and what behavior is expected. The vehicle lane widths, presence or absence of sidewalks and bicycle lanes, and presence or absence of buffering elements such as street trees and parked cars all influence a user's perceptions and resulting

[5] For this reason, in 2009 AARP endorsed the national Complete Streets Act and published a platform that urges Congress to include the Complete Streets Act in the authorization of the next federal surface transportation program. Retrieved June 25, 2009 from: http://www.aarp.org/makeadifference/advocacy/GovernmentWatch/StrongCommunities/articles/aarp_one_minute_guide_complete_streets_act.1.html#

behavior responses. Is it safe and pleasant to walk here? Can I safely cross the street? Can I drive fast here, or should I slow down?

Across the United States, departments of transportation are increasing their use of performance measures to assess the operation of transportation systems. However, assessment is generally limited to monitoring whether departmental goals are being achieved cost effectively or are generating net benefits, and how those benefits are being distributed. The impacts of particular transportation corridor design features on the local quality of life are generally not evaluated under these performance measurement systems. Although corridor design elements that support livable and sustainable communities have been identified through numerous research studies, their individual and cumulative quality of life impacts have been particularly difficult to quantify and measure, resulting in these elements being difficult to justify and prioritize, especially in times of limited funding. However, as global climate change continues to urge a new way of planning for mobility,[6] Complete Streets principles become more widely utilized and mandated,[7] and the numbers of people who walk and bicycle grow, the importance of quantifying the quality of life impacts of specific corridor design elements and developing measures to assess performance toward quality of life goals will only increase.

Within the planning and transportation fields, some research on the broadly conceived safety impacts of corridor design elements on all roadway users, including the impacts of narrower vehicle lane widths, parked cars, street trees, bicycle lanes, and wider sidewalks, has been conducted, and models of ideal "main streets" have been developed. However, few defensible performance measures exist for assessing the user safety, public health, economic vitality, multimodal mobility, and quality of life effects of various corridor design elements. Certainly, no comprehensive framework of such measures presently exists. Creating such a framework based on defensible research findings will assist transportation and planning professionals and policy makers in maximizing the potential public benefits associated with investments in

[6] Bernstein, L., Bosch, P., Canziani, O., Chen, Z., Christ, R., Davidson, O., et al. (2007). *Climate Change 2007: Synthesis Report*: Intergovernmental Panel on Climate Change, p. 57, 60.

[7] "Complete streets are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists and transit riders of all ages and abilities must be able to safely move along and across a complete street." National Complete Streets Coalition. (2009). *Complete Streets FAQ*. Retrieved June 1, 2009, from http://www.completestreets.org/complete-streets-fundamentals/complete-streets-faq/

highway right-of-way facilities and associated community networks, systems, and land use environments.

The adage justifying performance measures is "what gets measured gets done." In order to ensure that Caltrans is designing and building Complete Streets, the agency needs a more robust system of performance measures including new measures for non-motorized safety and mobility. Recognizing this need, the California Department of Transportation (Caltrans) initiated this project and through the University of California Transportation Center at Berkeley supported research into the effects of transportation corridor design features on user behavior and safety, the environment, public health, and community economic vitality, and the creation of defensible performance measures derived from the research that could be used by the Agency. The research effort was undertaken in two phases: a comprehensive Literature Review and the development of performance measures. The proposed *Complete, Green Streets Performance Measure Framework for Urban Arterials* outlined in this document represents the outcome of these research efforts.

Focus of the Performance Measure Framework

As evidenced by its name, the performance measure framework has three key aspects:

- Applicability to Urban Arterials
- A focus on creating Complete Streets
- A focus on creating Green Streets

This emphasis derives from the findings of the Literature Review and also reflects and adopts the terminology of two important street design "movements" that dovetail well with those findings.

Rationale for the Focus on Urban Arterials

The focus is on urban arterials, rather than all Caltrans highway types, because research and observation suggest these are the highways were most conflicts occur between motorized and non-motorized traffic, and where highway design has the biggest impact on local quality of life issues. As corridors that typically have a high concentration of commercial and retail attractions, often in addition to multi-family residential buildings, urban arterials act as a magnet to all types

of traffic. However, this may create a situation wherein pedestrians and bicyclists feel and are less safe, due to high amounts of vehicular traffic. As a corollary effect, people may choose not to walk or bicycle in and through these areas, thus reducing opportunities for physical activity. Vehicular traffic also negatively affects the immediate environmental quality, through releasing emissions during times of congestion and regular driving that pollute the air and contribute to the urban heat island effect, which increases the temperature of the urban area.

The Complete Streets Concept

Adopting Complete Streets terminology throughout the performance measurement framework recognizes and incorporates recently approved state policies, enacted state legislation, and internal agency directives that either encourage or require Caltrans to move toward a highway system that reflects the Complete Streets concept. Although Caltrans currently focuses on meeting state and regional goals of moving motor vehicles at a high level of service (LOS), there is a growing recognition of the fact that the existing roadway designs and standards often conflict with local, regional, and state needs and goals. Many of these goals are directed at encouraging pedestrian and bicycle travel and reducing air pollution from motor vehicles, and have come to be represented by the Complete Streets movement, which urges that transportation facilities be "**planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit riders, and motorists appropriate to the function and context of the facility**."

In California, *Assembly Bill 1358: The Complete Streets Act* was passed by the legislature in 2008, representing statewide recognition of the need to provide for all users of the transportation system.[8] In addition, Caltrans issued *Deputy Directive 64-R1: Complete Streets – Integrating the Transportation System*, which mandates the provision of bicycling and walking facilities along Caltrans' roadways (except where prohibited, such as limited access expressways).[9] DD-64-R1 evinces Caltrans' commitment to a multimodal transportation system, and AB 1358 builds on a

[8] Assemblyman Mark Leno. (2007). *The Complete Streets Act Fact Sheet*. Retrieved May 23, 2009. from http://www.calbike.org/pdfs/AB1358_Fact_Sheet.pdf.
[9] *Complete Streets - Integrating the Transportation System, DD-64-R1 C.F.R.* (2008)

national movement for Complete Streets,[10] as well as on local policies already in place throughout California. The Complete Streets concept and these two specific initiatives, which will be discussed in more detail later in this report, provide the central backbone around which the performance measure framework presented in this report was developed.

Complete Streets principles should benefit Californians in multiple ways. First, they should result in safer and more convenient roadways for Californians who walk, bicycle, or use transit. Second, the enhanced safety may encourage more people to choose active transportation, possibly resulting in greater health benefits from travel, as well as further increasing safety due to the principle of "safety in numbers."[11] Third, increases in active travel may lead to reductions in traffic congestion, auto-related air pollution, and the production of climate-changing greenhouse gases. Assemblyman Mark Leno estimated that if every Californian substituted just one car trip per month with a bicycle trip, nearly 4,000 tons of carbon dioxide would be saved per year.[12]

An important final aspect of building Complete Streets is that it makes fiscal sense, particularly as world demand for resources grows and the future looks to be more constrained regarding energy, building materials, and other goods. When sidewalks, bicycle lanes, transit amenities, and safe crossings are integrated into the initial design of a project, costly retrofits are avoided. In addition, providing for multimodal transportation from the beginning will have immediate benefits to roadway infrastructure, as there are instant alternatives to driving for citizens within the community. In general, automobiles, due to their mass and force, wear down roadways exponentially more quickly than bicyclists or pedestrians. Providing opportunities for travel via non-motorized modes may pay off dividends in the form of reduced maintenance per user.

It should be noted that although Complete Streets terminology is used throughout the proposed performance measurement framework, transit related issues are not addressed. This is because the Literature Review did not cover these issues, for reasons that will be explained more fully in

[10] For general information on the Complete Streets Movement, see www.completestreets.org
[11] Jacobsen, P. L. (2003). Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention, 9*, 205-209.
[12] Assemblyman Mark Leno. (2007). *The Complete Streets Act Fact Sheet*. Retrieved May 23, 2009. from http://www.calbike.org/pdfs/AB1358_Fact_Sheet.pdf

Chapter I. It is hoped that in the future, additional research can be done directed at filling this gap.

The Green Streets Concept

Another idea that is gaining momentum within transportation agencies across the United States is the Green Streets concept. Incorporating Green Streets terminology into the performance measurement framework is an attempt to encourage Caltrans to take a leadership role in this important environmental movement. Green Streets are defined as streets that maximize permeable surfaces, tree canopy and landscaping elements in order to:

- Divert stormwater from the sewer system and reduce basement flooding, sewer backups and combined sewer overflows;
- Reduce polluted stormwater entering rivers and streams;
- Improve pedestrian and bicycle safety;
- Reduce impervious surface so stormwater can infiltrate to recharge groundwater and surface water;
- Increase urban green space;
- Improve air quality and reduce air temperatures;
- Reduce demand on sewer collection system and the cost of constructing expensive pipe systems; and
- Address requirements of federal and state regulations to protect public health and restore and protect watershed health.[13]

Although no states have adopted Green Streets policies, many agencies are conducting research to determine the feasibility of incorporating some Green Streets principles into their roadway design practices. At the federal level, staff at the Environmental Protection Agency (EPA) are currently working to develop street design performance metrics that are inclusive of green infrastructure practices. At the regional level, Oregon's Metro Portland has adopted design guidelines for Green Streets and the City of Portland is actively building city streets in

[13] City of Portland, *Portland Green Streets Policy. Retrieved June 10, 2009, from* http://www.portlandonline.com/BES/index.cfm?c=44407

accordance with them. During a recent EPA webinar on Green Streets, many DOTs stated that their agency was beginning to address Green Streets principles through roadway design.[14]

It should be noted that although Green Streets terminology is used in the proposed performance measurement framework, the only Green Streets ideas that are addressed with new measures involve the provision of more street trees and the reduction of non-permeable surfaces along urban arterials. These were the areas that the researchers felt would be the place for Caltrans to start. It is hoped that future research efforts could lead to the creation of performance measures dealing with other green streets elements, particularly elements other than tree canopies that provide stormwater retention, such as bioswales or rain gardens.

Caltrans' Current Use of Performance Measures

Caltrans describes performance measures as "a necessary part of the California transportation plan…that can be used to determine whether the California Department of Transportation…is successfully meeting the state's transportation goals…"[15] The agency currently uses performance measures to monitor the performance and progress of the transportation system throughout the State of California, and is working with local communities to encourage the use of performance measures in decision-making.

Caltrans' current performance measures framework is structured around a set of strategic agency goals. While Caltrans' stated mission is simply to "improve mobility across California,"[16] it has developed a set of five goals that encompass a broader range of concerns.[17] The goals are:

1. **Safety**: Provide the safest transportation system in the nation for users and workers.
2. **Mobility**: Maximize transportation system performance and accessibility.
3. **Delivery**: Efficiently deliver quality transportation projects and services.
4. **Stewardship**: Preserve and enhance California's resources and assets.
5. **Service**: Promote quality service through and excellent workforce.

[14] Wilson, C. (2009). EPA Green Streets Policies. In E. Macdonald, R. Sanders & A. Anderson (Eds.) (Conversation about progress on green streets policies at the federal level. ed.). Washington, D.C.
[15] California Department of Transportation. (2009). *Transportation System Performance Measures*. Retrieved April 16, 2009, from http://www.dot.ca.gov/hq/tsip/tspm/
[16] California Department of Transportation. (2007). *Caltrans Strategic Plan 2007-2012*. Retrieved April 10, 2009. from http://www.dot.ca.gov/docs/StrategicPlan2007-2012.pdf. , 5.
[17] ibid., 6.

A series of objectives have been identified for each goal, and performance measures have been established that are intended to monitor the agency's progress toward each objective. The objectives set specific timeframes and numerical targets that are coordinated with the Strategic Plan that Caltrans adopts every five years.[18] The current performance measure framework contains 26 objectives supported by 57 performance measures, the full list of which can be found in Appendix A. Caltrans publishes quarterly Performance Measure Reports that track key indicators and annual reports on all of the adopted objectives and measures. At the end of each fiscal year, performance is measured against the targets set in the Strategic Plan and compared with the results of previous years. This annual review allows Caltrans to gauge overall progress toward objectives, and may be used to modify objectives if progress is made at a much different rate than expected.

The hierarchical structure of Caltrans' performance measurement system is based upon the following conceptual diagram and set of definitions:

Goal: The broad, long-term outcome or result the agency will work to realize.

↳ ***Objective:*** A finite target the agency will aim to meet, with the year and quantity of change explicitly stated. May contain both short and long-term dates and quantities.

↳ ***Performance Measure:*** The factor or trend that the agency will monitor, to track progress toward the objective and, ultimately, the goal.

Example (from Caltrans' existing Performance Measure Framework)

Goal: Provide the safest transportation system in the nation for users and workers.

↳ ***Objective:*** By 2008, reduce the fatality rate on the California state highway system to 1.00 per 100 million vehicle miles traveled and continuously reduce annually thereafter toward a goal of the lowest rate in the nation.

↳ ***Performance Measure:*** Fatalities per 100 million VMT on the California state highway system.

[18] ibid., 5.

Evaluation of Caltrans' Current Performance Measurement Approach

Although this report is focused on proposing new performance measures to enhance Caltrans' current system, it should be noted that few state transportation agencies in the United States have performance measurement frameworks that are more sophisticated or progressive. Like Caltrans, most DOTs have for decades concentrated primarily on driver mobility and safety, in keeping with the focus of the highway engineering profession. As that profession continues to expand to include a focus on pedestrians and bicyclists, however, and as the mitigation of harm to the environment continues to grow in priority, all of these agencies will need to measure additional aspects of the transportation system. It is the authors' hope that the new measures proposed in this report will allow California to emerge as a "best practice" state, once again in the vanguard position it has so commonly held.

Caltrans' current set of objectives and performance measures do not comprehensively set standards or measure the progress toward all the aspects of its safety, mobility, delivery, stewardship, and service goals that the recent Complete Streets directives and the growing widespread environmental concerns reflected in the Green Streets movement suggest it should. Specifically, there are no objectives or measures concerned with the safety and mobility of non-motorized travelers, nor are there measures concerned with environmental quality, other than one for litter clean-up. Perhaps the clearest example illustrating the shortcoming of the current measurement system is Caltrans' aforementioned measure for traveler safety: "The number of fatalities per 1,000,000 VMT." In this measure, Caltrans includes pedestrian and bicycle fatalities with driver fatalities, even though drivers routinely travel thousands more miles per year. Including all three modes in the same measure obscures the actual safety of pedestrian and bicycle travel, which is more accurately measured in the hundreds or low thousands of miles traveled per year. Although Caltrans attempted to address the lack of focus on non-motorized transportation in the Strategic Highway Safety Plan (SHSP), even the proposed SHSP goals do not fully address the area of pedestrian and bicycle safety, as will be explained in Chapter III.[19]

[19] California Department of Transportation. (2006). *California Strategic Highway Safety Plan Version 2*. Retrieved April 12, 2009. from http://www.dot.ca.gov/hq/traffops/survey/SHSP/SHSP-Booklet-version2_%20PRINT.pdf.

Because of these shortcomings, this research effort sought to develop new performance measures that would allow Caltrans to work towards state and national goals related to multimodal transportation, community quality and environmental stewardship.

Performance Measures: A Means Not an End

It is important to remember that performance measures are not the end in themselves, but rather a means to an end. The "end" in this case is a safer transportation system that improves mobility and traveler comfort while honoring the State of California through stewardship of environmental and fiscal resources, timely and quality delivery of projects, and service through its workforce.

Structure of the Report

This report contains five chapters, each with a number of sub-sections. Chapter I presents a summary of the research findings from the Literature Review and discusses their relevance and implications for urban arterials. Chapter II discusses the theoretical underpinnings of performance measurement and various approaches in the literature. It also profiles examples of "best practice" performance measures used by forward-thinking state transportation authorities to measure multimodal and "green" aspects of transportation system performance. Chapter III describes the federal, state, and agency policies and mandates that Caltrans is subject to relative to Complete Streets and environmental quality. Chapter IV presents the proposed *Complete, Green Streets Performance Measure Framework*, and includes discussion and recommendations related to setting targets and data collection. Finally, Chapter V provides conclusions and proposed next steps.

Although the research and proposals documented in this report are directed at Caltrans, it is hoped that the information provided, particularly the rationales for the creation of the performance measures, will be useful for state highway departments across the United States and similar agencies elsewhere.

CHAPTER I: FINDINGS FROM THE LITERATURE REVIEW RELATED TO URBAN ARTERIALS

Background

The Literature Review conducted during the first phase of this research project forms the base of the proposed *Complete, Green Streets Performance Measure Framework* that is the focus of this report. The Literature Review summarized the state of current knowledge regarding the effects of various corridor roadside design features on community quality of life issues. It addressed all transportation corridors under the jurisdiction of state highway departments, and so was concerned with controlled-access freeways, expressways, arterials, and "main street" highways. The focus was primarily on corridor roadsides, rather than vehicle roadbeds, because these are the interface zones between roadways and communities or the rural landscape. Because of their potential contributions to quality of life issues, attention was also paid to non-roadside design elements that contribute to traffic calming, walkability, and bikability, such as travel lane widths, crosswalks, and bicycle lanes. Funding and time constraints, and directives from Caltrans, necessarily limited the scope of the literature review and so transit-related roadside design elements, such as bus shelters or transit lanes, were not considered. As well, the quality of life effects of neighboring highway land uses were not addressed.

Rather than presuming to create a comprehensive review of every piece of applicable research, the researchers sought to include the most recent and relevant research. Approximately 165 studies, journal articles, and reports were reviewed for this phase.* In the summer of 2008, the Literature Review was circulated in draft form to a Technical Advisory Group composed of leading professionals and academics in the fields relevant to the literature. After incorporating their comments, the Review was published in late fall, 2008. It can be found on the University of California Transportation Center website at http://www.uctc.net/papers/878.pdf.

* Additional research published or deemed relevant to this project since the publication of the Literature Review has also been included in this section.

Findings from the Literature Review

The Literature Review was organized by broad category of subject matter related to user safety and behavior, health, community economic vitality, and the environment. Herein, only the findings applicable to *urban arterial streets* are presented because the focus of the performance measurement framework is on these streets, rather than all highways types, for the reasons explained in the Introduction to this report. In particular, findings from the Literature Review indicated that urban arterial streets were where most conflicts occur between motorized and non-motorized users because they typically offer direct movement routes and are usually lined with commercial establishments they attract pedestrians and bicyclists as well as vehicle drivers. As well, because of the higher number of pedestrians found there than on other highway types, how urban arterials are designed has a greater cumulative effect on local quality of life than does how other highway types are designed.

The research findings are summarized in seven sections focused on the following subject matters: driver safety, pedestrian safety, bicyclist safety, physical health and active transportation, psychological well-being, community economic vitality, and environmental effects.

Driver Safety

Studies regarding driver safety and roadside design elements that are applicable to urban arterials have focused mainly on the relationship between speed and driver safety, and whether the presence of roadside trees contributes to or reduces driver safety. Following is a summary of the key findings:

- On urban arterials of all configurations (two-lane undivided, three-lane with center turn, four-lane undivided, four-lane divided), wider lane widths (12-13 feet) are more likely to be associated with higher driver speeds than narrow lane widths (10 feet) (Fitzpatrick et al, 2000; Potts et al, 2007). Of interest related to this finding is that research indicates that wider travel lanes only marginally increase traffic capacity. Access management or signal synchronization can be employed to offset the minor reduction in capacity caused by designing 11 or 10 foot lanes (Daisa, 2006).
- Higher highway driving speeds are more associated with vehicle crashes and fatalities

than are slower speeds (Richter et al, 2006).

- Urban arterials with roadside trees, landscaping and pedestrian amenities—in other words, where expectations of lower driver speed is communicated through design—are associated with fewer vehicle collisions than are streets without these design elements, particularly far fewer pedestrian and bicyclist injuries and fatalities. (Dumbaugh, 2005, 2006; Mok et al, 2003). The reduction in accidents has been shown to hold true for arterials up to six lanes wide and with speeds up to 43 mph (Naderi, 2003).
- Roadside trees that are planted close to the roadway have a greater effect on slowing driver speeds on multilane highways than do trees planted further away. In the study from which these findings come, the closer trees were 6.6 feet from the roadway edge and the further trees were 14.76 feet away (Van der Horst and Ridder, 2007).
- On urban highways, wide traffic lanes and wide shoulders are positively associated with more run-off-roadway accidents whereas the presence of trees is negatively associated (Lee and Mannering, 1999).
- A national study of crash data found that roadside trees are involved in less than 1% of urban accidents and less that 0.001% of fatal urban accidents (Wolf and Bratton, 2006). In addition, a review of numerous research studies concluded that roadside trees posed no significant safety risk (Dixon and Wolf, 2007).
- Simulator studies indicate that drivers perceive urban streets with trees to be safer than urban streets without trees (Naderi et al, 2008).
- Simulator studies indicate that closely spaced street trees (25 feet apart) that come up to the intersection—if properly selected, adequately space, and pruned for high branching—do not create a strong visibility problem for drivers, but parked cars near intersections do (Macdonald, 2006).

These findings regarding driver speed are extremely important because driver speed affects not only driver safety but also that of pedestrians and bicyclists. If a driver is going too fast in an urban area, where a bicyclist could swerve to miss a pile of debris or a pedestrian could unexpectedly step off a curb, the driver will likely not have enough time to slow down and safely avoid hitting the unprotected pedestrian or cyclist (Ivan, Garder, & Zajac, 2001). Tragically, pedestrians sustain serious injuries when hit by a car going just 25 mph, a slow speed along

many urban arterials, and fatal injuries occur at 35 mph, which is a common speed in many urban areas (Leaf & Preusser, 1999).

As well, fast driver speeds are associated with low perceptions of safety for pedestrians and cyclists, creating a hostile environment that actually discourages walking and cycling, as will be discussed in more detail below (Litman, 2008; Parkin, Wardman, & Page, 2007). Therefore, the research suggests that as long as driver speeds on urban arterials remain high enough to endanger pedestrians and bicyclists, extra steps should be taken to both *protect* and *encourage* walking and bicycling.

The findings regarding roadside trees are important because of the multiple quality of life benefits trees provide, as will be discussed in later sections.

Pedestrian Safety

Concern for pedestrian safety on urban arterials is well-founded because research shows that most pedestrian fatalities (85%) occur on non-local streets (Litman, 1999; Anderson et al, 1997). Fortunately, the research also suggests that achieving greater pedestrian safety along urban arterials can be accomplished through design. The key findings from the Literature Review are as follows:

- Urban arterials that have "main street" characteristics (sidewalks, crosswalks, on-street parking, stop signs, mixed land use, posted speeds of 30 mph or less, large amounts of pedestrian traffic) were found to have much lower numbers of pedestrian injuries than those with a commercial strip character (no sidewalks, no traffic controls, wide curb cuts or no curbs at all, no on-street parking, posted speeds above 30 mph) (Ossenbruggen et al, 2001).
- In 2002, nearly 23% of motor vehicle/pedestrian crashes in the U.S. occurred while pedestrians were in a crosswalk, over 96% of these accidents occurred at intersections, and approximately one-third resulted in severe or fatal injury (Ragland and Mitman, 2007).
- Higher driver speeds are associated with less yielding to pedestrians at crosswalks (Ivan et al, 2001).

- Although marked crosswalks alone may be effective on low-volume (10,000 ADT or less) urban arterials, research clearly demonstrates that arterials with higher traffic volumes need additional safety features to consistently achieve driver yielding (Fitzpatrick et al., 2006; Zeeger et al, 2005).
- The presence of a marked crosswalk at an urban arterial intersection is associated with less mid-block jay-walking by pedestrians and slightly decreased driver speed approaching the intersection, particularly where there are multiple traffic calming treatments, such as overhead warning lights, pedestrian refuge island, pedestrian activated in-roadway lighting, and advance yield signage (Dulaski, 2006; Sisiopiku and Akin, 2003; Huang & Cynecki, 2001; Knoblauch et al, 2001).
- Marked crosswalks at unsignalized locations along multi-lane arterials (intersections or mid-block) have been found to be dangerous for pedestrians because drivers in far lanes often fail to stop. However, such crosswalks become much safer when they supplemented with flashing lights or red beacons (95% motorist compliance rates were observed), especially on all multi-lane roadways and in areas with high volumes of fast-moving traffic (Fitzpatrick et al., 2006; Ragland & Mitman, 2007; Zegeer et al., 2005).
- At both signalized and unsignalized locations along urban arterials, crosswalks supplemented with in-pavement warning lights were found to be highly successful in encouraging driver yielding and somewhat successful at decreasing pedestrian jay-walking, particularly in areas of moderate to intense pedestrian traffic (Abdelghany, 2005; Godfrey & Mazzella, 2000; Hakkert et al, 2002; Rousseau et al, 2004; Whitlock and Weinberger Transportation, 1998).
- Along urban arterials, pedestrian countdown signals at intersections were found to be associated with safer crossing behavior by pedestrians (Eccles, Tao, & Mangum, 2004).
- In a study of New York City intersections where right turns on red were allowed, the installation of leading pedestrian intervals was associated with significantly reduced crash rates (King, 2000).
- In a given area, the likelihood of a pedestrian being injured or killed by a collision with a motorist decreases as the number of people walking increases. The principle of "safety in numbers" suggests that to increase pedestrian safety overall, greater rates of walking should be encouraged, as this leads to increased driver awareness and subsequently safer

driving around pedestrians (Jacobsen, 2003).

Bicyclist Safety

Research related to the design of urban arterials and bicycling safety is not as yet very robust. Most research studies concerning the safety of particular design elements have focused on bicycle sidepaths, long eschewed from U.S. transportation engineering practices. However, because many research studies are currently in progress it is likely that the field will evolve quickly to provide a greater understanding of how various treatments, such as painted bicycle lanes, bicycle boxes and separate bicycle signals, affect bicycle safety. Meanwhile, Jacobsen's study on "safety in numbers," cited above, applies equally to bicyclists, as can be seen in the statistics from Portland's years of bicycle counts and crash data from bridge crossings (Portland Office of Transportation, 2008).

Considerable literature does exist on bicyclists' preferences regarding bicycle facilities, which are often linked to their perceptions of safety, as well as associations between the presence of bicycle facilities and increases in the number of bicycle trips. This literature is discussed below, in the Bikability section.

Physical Health and Active Transportation

Research suggests that good physical health leads to better quality of life and that community design that encourages active living can contribute to better physical health. A growing understanding of these cross effects combined with growing concerns about what seems to be an obesity epidemic in the United States, has led to increased linkages between the public health fields and the built environment fields. For instance, the American Academy of Pediatrics recently released a policy statement on the importance of designing communities that encourage children to use active transportation modes (Committee on Environmental Health - American Academy of Pediatrics, 2009). The authors emphasize that children and others need more opportunities for "incidental physical activity", such as the ability to walk or bicycle to school or to the store for an unplanned trip. The importance of providing sidewalks and bicycling facilities for active travel and recreation is underscored. A recent report by Cycling England details all of

the ways in which bicycling can help fight obesity and other chronic diseases (Cavill & Davis, 2007), and numerous studies have found that walking and bicycling can significantly contribute to meeting nationally recommended goals for physical activity (Cooper, Page, Foster, & Qahwaji, 2003; Frank, Saelens, Powell, & Chapman, 2007; McDonald, 2007; Saelens, Sallis, Black, & Chen, 2003).

The Literature Review focused on research related to walkability and bikability. Key findings are the following:

Walkability

- Numerous research studies suggest that urban form influences whether or not a community is walkable. Elements found to be positively associated with walkability that have applicability to the design of urban arterials include the connectivity of a community's street system, the presence of sidewalks, and pedestrian pathways that are visually stimulating and scaled to pedestrians (Handy, 2005; Saelens & Handy, 2008; Southworth, 2005).
- People who live in walkable neighborhoods walk more than those who do not, even controlling for self-selection, and that they are generally less likely to be overweight or obese (Frank et al., 2007; Southworth, 2005; Saelens et al., 2003).
- Related literature suggested that people are willing to walk farther than commonly assumed (one-half mile versus one-quarter mile) for utilitarian purposes (Schlossberg, Weinstein Agrawal, Irvin, & Bekkouche, 2007).
- Research on pedestrian level of service (LOS) at signalized intersections indicates that conflicts with turning vehicles, as well as the volume and speed of perpendicular traffic, have the most negative effect on pedestrians' perceptions of comfort (Petritsch et al., 2004).
- Along arterial streets, perceived pedestrian Level of Service (LOS) was found to decrease in correlation with the total width of driveway and intersection crossings, as well as the amount of traffic on the adjacent roadway (Petritsch et al, 2006).
- Pedestrian LOS for mid-block crossings was found to increase as the width of painted or raised medians increased, and when a crosswalk and/or pedestrian signals were present

(Baltes & Chu, 2002).

- Pedestrians were found to be more sensitive to delay than those driving or taking transit, perhaps due to climatic concerns (Rajamani et al, 2002).
- The presence and number of street trees was found to positively influence the propensity to walk along a street (Lee & Vernez Moudon, 2006, 2008).
- Streets with high volumes of traffic may act as barriers to pedestrians attempting to cross them, and thus may discourage walking (Litman, 2008; Schlossberg & Brown, 2004).

Bikability

Although not much research exists regarding bicyclists' preferences for new types of bicycle facilities, solid research on the use of and preference for bicycle lanes and paths has been conducted in the last few years. In particular, cities such as Portland, Oregon, and New York City, New York, continue to innovate and publish their findings regarding new bicycle facilities in the United States. The findings below represent the best of what is currently known and applicable to urban arterials.

- A national study found that in cities with populations over 250,000, each additional lane of Class II bicycle lanes per square mile was associated with approximately one point increase in the percentage of bicycle commuters (Dill & Carr, 2003).
- Likewise, a study at the neighborhood scale found a positive association between the presence of bicycle lanes and paths in a neighborhood and the amount of bicycling in it (Lee & Vernez Moudon, 2008).
- One survey found that perceptions of safety while cycling were associated with frequency of cycling, and that each additional mile of bicycle lane in a city was positively associated with a 5% increase in the likelihood of people to own a bicycle and to have ridden it in the week prior to the survey (Xing, Handy, & Beuehler, 2008).
- An analysis of comprehensive investment in bicycling facilities in Portland, Oregon, found that a 215% increase in the bicycle network was matched by a doubling of the overall bicycle commute share, and a 210% increase in the number of bicycle trips in the surrounding areas (Birk & Geller, 2005).
- A highly connected bicycle network leading to desirable destinations has been found to be positively associated with the number of bicyclists in a city (Dill & Voros, 2007;

Douma & Cleaveland, 2008; Birk & Geller, 2005).

- Bicyclists were found to be more sensitive to delay than those driving or taking transit, perhaps due to climatic concerns (Rajamani et al., 2002).
- Streets with high volumes of traffic may act as barriers to bicyclists attempting to cross them, and thus may discourage bicycling (Litman, 2008; Schlossberg & Brown, 2004).
- A study using GPS data from Portland, Oregon, found that cyclists riding for utilitarian purposes rode mainly on facilities with bicycle infrastructure, and that nearly 30% of the travel occurred on streets with bicycle lanes. This study also found that bicyclists often go out of their way to use bicycle facilities, even when it lengthens trip time (Dill & Gliebe, 2008).
- Several surveys have documented that bicyclists strongly desire more bicycle lanes and trails (Dill & Voros, 2007; Gonzales, Hanumara, Overdeep, & Church, 2004; Vernez Moudon et al., 2005; Wardman, Tight, & Page, 2007).
- Other studies have evaluated stated preferences using dynamic modeling to determine the balance between commute time and facility quality. The results revealed a clear willingness to travel several minutes longer to get to and ride in a bicycle lane in order to avoid riding in mixed traffic (Hunt & Abraham, 2007; Tilahun, Levinson, & Krizek, 2007).
- An analysis of perceived cycling risk and route acceptability found that high amounts of auto traffic were associated with increased perceptions of cycling risk, which can be helped, but not completely alleviated, by the presence of bicycle lanes (Parkin, Wardman, & Page, 2007).
- Research on bicycle LOS found that the presence or absence of a bicycle lane was the most commonly cited reason for giving a roadway a high or low score, respectively (Petritsch et al., 2006).
- Where motorists and bicyclists share lanes, "sharrows" have been found to encourage safer driving and biking behavior (Alta Planning + Design, 2004).

Other Aspects of Physical Health

Several studies have documented an increased risk of several health problems, including respiratory ailments, infant mortality, and cancers, in areas with high volumes of diesel truck and

auto traffic (Houston, Wu, Ong, & Winer, 2006; Kim et al., 2004; Pearson, Wachtel, & Ebi, 2000; Wjst et al., 1993). In addition, the United States Global Change Research Program recently released a report detailing the risks to health global climate change, which include increased risk of extreme weather events and deaths related to extreme heat (such as heat stroke), reduced air quality, and increases in contagious diseases and pollen production (Karl, Melillo, & Peterson, 2009). It is therefore increasingly important to mitigate air pollution and the overall effects of global climate change, including rising urban temperatures, as much as possible. The findings described in the Environmental Effects section below demonstrate that the design of urban arterials can help.

Psychological Well-being

Psychological well-being is an important quality of life issue and evidence suggests that urban form can have a positive or negative impact. In particular, considerable literature links the presence of trees and greenery with psychological well-being. Although few studies have dealt directly with the psychological effects of greenery along urban arterials, the findings from studies of other spaces can be extrapolated to arterials. The main findings are as follows:

- Time spent viewing greenspace or being outside in a calm environment enhanced positive feelings both directly and indirectly by taming stress and frustration, and was associated with improved performance on subject tests (Kaplan, 1995; Maller, Townsend, Pryor, Brown, & St. Leger, 2005; Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1993; Pretty, 2004; Ulrich, 1986).
- The presence of roadside landscaping has been tied to reduced traffic stress for both drivers and those who live along heavily traveled corridors (Cackowski & Nasar, 2003; Parsons et al., 1993).
- Other research found that people generally prefer to live near greenery and mature trees, and that in a lower income area, greenery and mature trees near apartment buildings were associated with greater community interaction (Kuo, 2003).

Community Economic Vitality

Whether or not a community has economic vitality has an important impact on local quality of

life. Unfortunately, little research has been done on the relationships between street design elements and community economic vitality. However, the research that has been done underscores that, as prime commercial areas, urban arterials should provide opportunities for pedestrian and bicycle access, as well as amenities such as street trees that enhance pedestrian comfort and therefore encourage foot traffic. The following are the key findings from the Literature Review:

- Several studies have found that pedestrians, transit users, and bicyclists routinely visit stores along commercial strips in urban areas more often and spend more money overall than do patrons who drive. In two of the studies, pedestrian intercept surveys found that patrons would prefer removing one lane of parking and installing bicycle lanes or widening the sidewalk by a ratio of 4:1 and nearly 5:1, respectively. Results from the third survey also suggested that widening the sidewalk could be very beneficial for the businesses in the area (San Francisco County Transportation Authority, 2009; Schaller Consulting, 2006; Sztabinski, 2009).
- Pedestrian improvements to a downtown business area were found to be associated with both increased pedestrian traffic and increased property values (Whitehead, Simmonds, & Preston, 2006).
- Consumers were found to prefer business districts that have landscaping and trees, including those along main street arterials (Wolf, 2004a, 2004b, 2005).

Environmental Effects

The theme throughout the environmental literature was that trees in urban areas tend to be overwhelmingly beneficial for communities. In particular, urban trees help mitigate air and water pollution, mitigate urban heat island effects, reduce emissions, retain stormwater, and reduce energy consumption through shading adjacent buildings (Akbari et al, 2001; Heisler, 1974; McPherson & Simpson, 2003; Scott et al, 1999; Simpson, 1998; Streiling & Matzarakis, 2003). The cumulative benefits of a community's entire urban forest can be substantial. A study of Sacramento County's urban forest concluded that it contributes to approximately $20 million dollars in annual energy saving through shading and the reduction of wind speed and air temperature (Simpson, 1998). Another study concluded that California's 177 million urban trees reduce energy used for cooling by 2.5%, for a total savings of almost 1.5 billion dollars annually

(McPherson and Simpson, 2003). A study of Davis's public urban forest, consisting primarily of street trees, calculated a net benefit to the city of $66 per tree. A study of rainfall interception by trees in Santa Monica, California found that they intercepted 1.6% of total annual precipitation, annually saving the city over $110,000 in avoided stormwater treatment and flood control costs associated with water runoff (Xiao and McPherson, 2002). A study that modeled urban forest effects on the urban heat island concluded that adding 5 million trees to the Los Angeles metropolitan area would result in an air temperature reduction of 5-7˚ F in the hottest areas (Akbari et al, 2001).

How does all this relate to urban arterials? The environmental benefits of trees are incredibly important for urban arterials because the high amounts of traffic on these streets contribute to air and water pollution, while the high surface area of non-permeable asphalt contributes to the urban heat island and increased stormwater run-off. In addition, urban arterials tend to be lined with numerous energy-consuming buildings. At the same time, they are places where people live, work, shop, and relax and so it is important to design urban arterials in ways that contribute to people's physical comfort on them. As well, common sense suggests they should be designed to help mitigate the local harmful environmental effects they cause. Several complimentary strategies can be employed to accomplish this. One strategy is to design urban arterials with facilities for pedestrians and bicyclists, in order to encourage people to drive less and thereby decrease both vehicle energy use and air pollution. A second strategy is to reduce the amount of heat absorbing surfaces on urban arterials, particularly dark asphalt, to address the urban heat island effect. A third strategy is to reduce the amount of non-permeable surfaces on urban arterials, to mitigate stormwater run-off. A fourth strategy, which contributes to mitigating all the environmental problems, is to plant significant shade-giving trees along urban arterials.

Specific key findings about trees from the Literature Review that are applicable to urban arterials are the following:

- Street trees in urban areas provide significant environmental benefits over their lifetimes that result in significant cost savings to communities. Large trees provide significantly greater heating and cooling energy savings, air pollution absorption, and stormwater runoff reduction than smaller trees. Quantification efforts from a Washington and Oregon

study suggest that a large street tree (46 feet tall; 41-foot spread) provides a benefit of $55/year; a medium tree (39 feet tall; 31-foot spread), approximately $25/year; and a small tree (28 feet tall; 25-foot spread), approximately $5/year (McPherson et al, 2002).

- A study of a community tree-planting program in Iowa found that each newly tree planted annually sequestered 1.5 pounds of carbon per year and removed significant amounts of ozone and particulate matter. (Thompson et al, 2004).
- Trees with wider trunks remove significantly more pollution than those with small trunks. For example, a tree with a 2.5-foot diameter trunk removes 65% more than trees less than 3 inches in diameter (Thompson et al, 2004).
- In the hot climate of Davis, California, shaded asphalt pavement was found to be 20 degrees cooler than unshaded pavement (Scott et al, 1999).
- Asphalt parking areas with 50% tree coverage were found to be associated with 5% lower vehicle emissions than unshaded areas (Scott et al, 1999).
- Depending on crown density, street trees allow only 2-40% of solar radiation to reach the ground surface, (Heisler, 1974).
- A study of the effects of tree shade on asphalt concrete pavement performance found that tree shading contributed to better pavement conditions and longer material life (McPherson and Muchnick, 2005).

Implications for the Design of Urban Arterials

When viewed holistically, the cumulative research findings presented above seem to recommend some key guidelines for the design of urban arterials:

- Consider street designs that contribute to lower driver speeds, particularly narrower travel lanes, in order to contribute to driver, pedestrian, and bicyclist safety.
- Install sidewalks, crosswalks, and supportive pedestrian infrastructure in a systematic and correlated manner to give pedestrians the best chance of walking safely along any roadway and to increase their perceptions of safety. The more pedestrians there are on the road, the safer each will be.
- At signalized intersections provide pedestrian countdown intervals and leading pedestrian intervals as well as crosswalks.
- Where pedestrian crosswalks occur at uncontrolled locations, particularly along

multi-lane roadways, provide supplementary safety features such as in-pavement warning lights or overhead flashing beacons.

- Provide bicycle lanes, bicycle paths, or sharrows to build a network on which bicyclists feel comfortable and can interact safely with traffic. The more bicyclists there are on the road, the safer each will be.
- Provide trees and greenery, particularly along stretches of highway where commercial uses attract people and where people live, in order to enhance psychological well-being and community economic vitality.
- Plant shade-giving sidewalk trees on close spacing to create a continuous canopy along the street in order to increase the physical comfort of pedestrians and cyclists.
- Provide large shade-giving deciduous trees to mitigate local air pollution, stormwater runoff, and the urban heat island effect, contribute to energy savings in surrounding buildings, and extend pavement life.

These guidelines form the basis for the performance measurement framework presented in Chapter IV, and are in keeping with both Complete Streets and Green Streets principles, which will be discussed in Chapter III along with policies related to these concepts that effect Caltrans. First, however, we turn to a discussion of key issues concerning performance measures followed by examination of best practice examples of performance measures used by transportation agencies.

CHAPTER II: PERFORMANCE MEASURES IN THEORY AND PRACTICE

Much literature exists regarding the formulation and use of performance measures in governmental agencies, business, and industry, including a host of literature directed at transportation agencies. In researching the foundational principles of performance measurement, several documents emerged as most useful because of their clear articulation of key concepts, important issues, and the variety of possible measurement approaches. These documents, upon which much of this chapter is based, include a national report on best practices in performance measurement, the proceedings from a major transportation conference focused on performance measures, a report on the development of multimodal performance-based planning from the National Cooperative Highway Research Project (NCHRP), and guidelines on creating performance measures for use within context sensitive solutions, among others.

Why Measure?

Performance measures are used to gauge progress for a simple reason: "what gets measured gets done."[20] More specifically, measuring performance provides an avenue for accountability for stakeholders and management, generally resulting in improved communication between the various groups; helps to gauge efficiency and effectiveness within an organization; provides clarity about the planning process and agency expenditures; and creates a direct feedback loop to foster improvement over time.[21] To quote Osborne and Gaebler in *Reinventing Government*:

- If you don't measure results, you can't tell success from failure.
- If you can't see success, you can't reward it.
- If you can't see failure, you can't correct it.[22]

[20] United States Government. (1997). *Serving the American Public: Best Practices in Performance Measurement*. Washington, D.C., 11.
[21] Peyrebrune, H. L. (2000). *Performance Measures to Improve Transportation Systems and Agency Operations: Report of a Conference.* Paper presented at the Conference on Performance Measures to Improve Transportation Systems and Agency Operations, Irvine, California,20.
[22] ibid., 48.

Most performance measurement systems are based on the following hierarchy: broad goals, objectives that state the target year and desired change, and the performance measures that will be used to track progress toward objectives and goals.

It is critical that the objectives reflect the goals and are clear about the desired direction and magnitude of result. The performance measures must be identified in response to the objectives and goals to ensure that the desired results are obtained, rather than just what may be easier to gauge, and that the measures will in fact reflect progress toward the goals. A key part of performance measurement is its ability to provide accountability, which is generally achieved through monitoring and feedback to the process, in addition to communicating and reporting results to various stakeholders.[23]

Performance measures are often defined to give feedback about systems, and therefore influence the decision-making process. Although there was mention of concern about decision-makers "chasing" performance measures to achieve high marks,[24] the literature was clear that although these measures can influence the process, they do not replace it.[25] Project selection is often highly political and may depend on the presence of constrained funding. Performance measures should therefore be used to help make the best decisions possible under the circumstances and within the directive of over-arching policies. Ideally, performance measures will clarify the trade-offs that occur between design alternatives, thus providing transportation professionals with an accepted "neutral" guidance system.

With that said, however, there was also recognition in the literature of the need for transportation agencies to create goals, objectives, and measures that resonate with society and values for quality of life. Several speakers at the *Conference on Performance Measures to Improve Transportation Systems and Agency Operations* suggested that measures that are easy do not

[23] ibid., 19.
[24] Cambridge Systematics, Inc. (1999). Multimodal Transportation: Development of a Performance-Based Planning Process: National Cooperative Highway Research Program, 2-8.
[25] Peyrebrune, H. L. (2000). 24-25.
Cambridge Systematics, Inc. (1999). ES-4.

necessarily completely reflect society's greater goals, and that allowance must be made for struggling through incompatible measures such that quality of life is maximized.[26]

Creating Successful Performance Measures

In 1997, then-Vice President Al Gore commissioned the *National Performance Review* (NPR) to examine best practices in performance measurement in the United States.[27] The authors defined performance measures as "quantitative or qualitative characterization(s) of performance" based on the progress made toward pre-determined goals after certain amounts of time. Although specific goals depend on the industry and context, it is common for goals to focus on efficiency, quality, outcomes, and effectiveness. The NPR lists several elements critical to the successful development of performance measures, including:

1. Leadership and alignment with a strategic direction,
2. A conceptual framework that includes target setting and benchmarking,
3. Effective communication about the process and the results both internally and externally,
4. Results that provide intelligence rather than just gather information,
5. Accountability for the results, and
6. A system of compensation and positive reinforcement.[28]

The performance measurement framework developed in this research project incorporates a number of these elements, specifically alignment with Caltrans' strategic directions, a conceptual framework for target setting and benchmarking, a means for both internal and external communication, and the gathering of real intelligence about the performance of urban arterials in relation to Complete Streets and Green Streets principles. Incorporation of the other critical elements would fall to Caltrans in their implementation process.

The NPR also provides guidance on how to develop individual performance measures. It suggests that performance information should be used to, among other things, inform resource allocation decisions, understand gaps between vision and reality, and influence reconsideration

[26] ibid., 35.
[27] ibid.
[28] ibid., 2-4, 57
See also: Cambridge Systematics, Inc. (1999), ES-3.

of current practice. Above all, performance measures should encourage taking appropriate action. The NPR recommends that in order to be successful, performance measures should be:

- Resonant with customer values,
- Able to show both a snapshot and a trend of progress toward goals,
- Simple,
- Easily understandable,
- Sensible,
- Repeatable,
- Timely,
- Sensitive, and
- Economical with regard to data collection.[29]

These directives helped shape the proposed performance measures for urban arterials developed in this research project. In particular, efforts were made to develop measures that were based in policy and legislation reflective of customer values, influence a reconsideration of current practice, and capture both snapshots and trends. As well, recommendations for data collection focus on economical methods, drawing on existing data sources whenever possible. More is discussed about this below and in Chapter IV.

Many federal and state agencies have adopted performance measure frameworks to evaluate their operations. The Department of Health Services in Wisconsin (DHFS) is one such agency and its approach provides useful insight to how a performance measurement system is implemented. The DHFS suggests a five-stage approach to performance measurement:

1. Identify your desired accomplishments at the highest level reasonable,
2. Identify the performance measure(s) you will use to determine if you are reaching your desired accomplishment,
3. Obtain baseline or trend information on your performance measure(s),
4. Obtain comparison data and set a target or standard that you are trying to reach for each performance measure, and

[29] ibid., 24, 79
See also: Training Resources and Data Exchange. (1995). *How to Measure Performance: A Handbook of Techniques and Tools*. Washington, D.C.: U.S. Department of Energy, 1-5.

5. Gather and report performance data.[30]

This systematic approach contributed a conceptual underpinning to the process used by the researchers when brainstorming possible performance measures.

Context Sensitive Performance Measures

In 2004, the National Cooperative Highway Research Project (NCHRP) published a report to guide state Departments of Transportation about how to be more context sensitive in their development and usage of performance measures.[31] Depending on the context and specific needs of the organization, they encourage a balance of performance measures that gauge progress at both the project and the organization level, and that evaluate both planning and design processes and post-occupancy outcomes.

NCHRP recommends that process-oriented performance measures should reflect open, early, and continuous communication with all stakeholders, contain multi-disciplinary input, and be tailored to involve the public with consensus-building. Outcome-oriented measures should reflect community values, and be sensitive to scenic, aesthetic, historic, and natural resources.

In order to mesh with Caltrans' existing performance measurement system, the proposed performance measures for urban arterials developed in this report are outcome-level measures. However, Caltrans is currently moving in the direction of implementing context-sensitive design approaches recommended by NCHRP. As it does so, the agency should develop a framework of additional performance measures that address evaluating the process components of its corridor design undertakings.

What to Measure

Agencies can measure performance through examination of inputs, which examine the resources dedicated to a program (e.g., dollars per mile of sidewalk); outputs, which examine the products

[30] Strategic Planning Unit. (2001). *A DHFS Simple Guide to Performance Measurement*. Madison, WI: Wisconsin Department of Health Services, 9.
[31] TransTech Management, Inc., Oldham Historic Properties, Inc., & Parsons Brinckerhoff Quade & Douglas, Inc. (2004). *Performance Measures for Context Sensitive Solutions - A Guidebook for State DOTs*: Federal Highway Administration.

of the program (e.g., number of miles of sidewalk); or outcomes, which examine the impact of the products on the overall goals (e.g., improved sidewalk surface).[32] Although it may be easier to measure inputs, the outcomes are what tell the transportation agencies how close they are to meeting their objectives, and what the stakeholders most often want to know. Therefore, agencies are encouraged to measure outcomes if possible, and to measure outputs when outcomes are too difficult to measure; inputs almost never provide the final desired information, although they help management understand how resources are being used.

It can be tempting to base performance measures on information that is readily available; however, this practice should be avoided, and measures should be defined to provide the information that is most helpful to the agency. In addition, although transportation agencies do not fully control all outcomes associated with implemented projects, particularly behavioral outcomes, (e.g., several factors other than the presence of a sidewalk go into the decision to walk to work), they should still be encouraged to use measures specific enough to provide concrete diagnostic information.[33]

Setting Targets and Determining Data Sources

The process of setting targets is a key part of creating a successful performance measurement system. The U.S. Department of Energy suggests that each target should be far enough off that the organization has to work to reach it, but close enough that there is a realistic chance of meeting it within a defined time period.[34] Cambridge Systematics recommends setting targets by defining the agency's current position in the various areas and then determining what a reasonable improvement would be.[35] These should include evaluation criteria that can be measured in the near-term, but which are related to longer-term measures and goals. In this way, targets provide something to reach for while maintaining morale in the organization.

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[32] Peyrebrune, H. L. (2000). 6, 77.
[33] Cambridge Systematics, Inc. (1999)., 3-6.
[34] Training Resources and Data Exchange. (1995). *How to Measure Performance: A Handbook of Techniques and Tools*. Washington, D.C.: U.S. Department of Energy, 1-15.
United States Government. (1997). *Serving the American Public: Best Practices in Performance Measurement*. Washington, D.C., 8, 10.
[35] Peyrebrune, H. L. (2000). 27.
Cambridge Systematics, ES-5.

In addition, the literature recommends that targets should be set using currently available data whenever possible, as using existing data sources minimizes the time and resources needed to collect the data and evaluate progress.[36] In some cases, however, existing data cannot provide the information needed. While speaking at the aforementioned *Conference on Performance Measures,* Tarek Hatata, President of System Metrics Group, Inc., put it this way:

> One of the guidelines, and one of my issues with performance measurement in general, is that even though relying on existing data makes it faster to implement, we are going through a revolution of information technology and information data sources…Maybe we need to change and put additional funds into it, as opposed to relying on the same data, just trying to manipulate it, and making it into something else. It may be why things haven't changed in 50 years—because there is a reluctance at every level, the regional, state, and federal levels, to think outside of the box and say, ''Let's collect new data, brand new data that may give us brand new answers.''[37]

In order to get these "new answers", new data sources will have to be created when there is no appropriate substitute and no other way to accurately gauge progress toward the desired goals.

The proposed *Complete, Green Streets Performance Measure Framework* was designed to make use of existing data sources whenever possible. The researchers recognize that the administrative cost of creating new data collection and analysis methods could serve as an obstacle to the adoption of these new measures. However, because Caltrans does not have a long history of incorporating non-motorized modes into all aspects of its work, it will not be possible to measure progress towards Complete, Green Streets without creating some new data collection/analysis processes. In some cases, an action already undertaken by the Agency will need to be expanded so that additional data can be collected (e.g. the annual pavement survey). For other proposed measures, entirely new data collection systems are required (e.g. counting bicycle and pedestrian trips).

[36] ibid., 52.
[37], ibid., 127.

When to Measure

When an organization using a performance measurement framework is involved in building projects and maintaining a built infrastructure, like Caltrans, the issue arises as to when the performance measures should be used: during the design phase or after projects are built.[38]

Decision-making measures occur at the beginning of the decision-making process and can therefore influence the type of project implemented so that the organization's goals are more likely to be met in the near term. These measures are commonly directed toward internal audiences, such as management and staff within the organization.

Post-occupancy measures, on the other hand, occur after project completion, and serve to "grade" the project on how well it meets pre-determined goals. These measures are often used for external audiences, such as citizen stakeholder groups who are affected by the outcomes of the projects. Also, post-occupancy measures can be applied to individual projects, to all projects completed during a specified time-period, or to the entire system.

Decision-making and post-occupancy measures can be used discretely or together as part of a comprehensive system of performance measurement. The *Complete, Green Streets Performance Measure Framework* includes measures that can be used during the decision-making stage of Caltrans' work (i.e., when decisions are being made about which urban arterial projects to pursue, or which design elements to include in planned urban arterial projects), and for on-going monitoring of completed projects. Some proposed measures for completed projects evaluate only those projects completed during a specified time period (i.e., quarterly), while others measure the performance of Caltrans' entire urban arterial system.

Assigning Value

One complex aspect of performance measurement is the assignment of value to certain goals or strategies. Perhaps the most common way of doing this is through the process of monetization, which incorporates direct and indirect costs to assign a dollar value to alternative proposals.

[38] Weisbrod, G., Lynch, T., Meyer, M., Venner, M., Moses, S., Piercy, B., et al. (2007). *Monetary Valuation Per Dollar of Investment in Different Performance Measures* (No. 08-36, Task 61). Washington, D.C.

However, it is important to remember that not every impact can accurately be represented in monetary terms. Therefore, an alternative way is deciding a hierarchy of goals and choosing a design or implementation strategy that best fits that hierarchy. These two methods are discussed below.

Monetization

When an organization strives to meet several diverse goals with limited resources, it can be difficult to prioritize certain goals over others. Many organizations choose to monetize the expected benefits and costs in order to develop a hierarchy. A broad study of monetary valuation with regard to the effects of the transportation system, sponsored by the NCHRP, concluded that both direct and indirect effects should be monetized in order to create a holistic picture of a system.[39] Direct effects include, but are not limited to:

- Accessibility (including Americans with disability),
- Mobility,
- Operations Efficiency (Average Travel Time and Distance),
- Customer satisfaction, and
- Safety.

Indirect effects measure the impact on people and the environment, and can include:

- Economic development,
- Environmental quality (air, water, land),
- Health,
- Quality of life, and
- Security.

The authors recommend that cost and benefit values may be determined by a variety of methods, including:

- Damage costs, which reflect the total estimated amount of economic losses produced by an impact;

[39] Weisbrod et al., 5.

- Control or prevention costs, which are estimated based on what it would cost to prevent, control, or mitigate an incidence after it occurred;
- Hedonic methods, which infer values for non-market goods from their effect on market prices, property values, and wages;
- Contingent valuation, which infers costs by surveying a representative sample of individuals about how much they value a particular non-market good;
- Compensation rates, which are legal judgments and other compensation rates for damages that can be used as a reference for assessing non-market costs; and
- Shadow prices, which reflect visitors' actual travel-related costs incurred (non-monetary expenses and time costs) as a way to measure the "consumer surplus" provided by making a trip. These prices may also be used to assign costs to emissions and resource loss.[40]

While monetization may be convenient, it routinely faces the challenges of establishing a hierarchy of values and quantification of qualitative impacts. The challenge of the hierarchy of values refers to the reality that for different stakeholders, different aspects of a transportation system may be prioritized. For some, throughput and efficiency (direct effects) may be the most important or valuable aspects, while for others environmental preservation and perceptions of comfort and safety (indirect effects) may be the most important. Although monetization may seem like a neutral way to value benefits and costs, this is often not the case due to the reality that many of the costs and benefits associated with transportation are not directly measured in dollars. This leads to the second challenge, which is that of quantification. Each stakeholder group may have a different opinion on the value of a life saved or the cost of treating or precluding air pollution. Because there are no universally-accepted values for many important impacts of transportation projects, subjectivity is almost always involved in the quantification of these impacts.

Even though the process is imperfect, however, it is important to quantify these effects as well as possible, to thwart the tendency of decision-makers to focus on "easy-to-measure impacts."[41]

[40] Weisbrod et al.12-13.
[41] ibid., 11.

Table 1 gives an example of some of NCHRP's suggested valuations for direct and indirect effects.

Table 1: Assessment of Monetization Potential of Categories[42]

Impact Class	Comments on How These Impacts or Benefits are Monetized
Accessibility	The monetary value for accessibility can be some form of the economic value of the activity that is occurring on the land enabled by transportation investment. Or the value of the travel time associated with accessing a particular activity might be a surrogate for the monetary benefit associated with such a trip (for example, such an approach is used for valuing recreational trips to major parks).
Mobility	The value of mobility improvements is commonly measured as the value of time and cost savings resulting from traffic congestion reduction or transit service improvement. For freight, there can be an economic measure of improved productivity for the freight sector.
Safety	Monetary measures can be developed for safety performance, based on the societal cost of vehicular crashes (from NHTSA) and the cost of injuries and death (by FHWA and other agencies).
Customer Satisfaction	It is not clear how to monetize customer satisfaction, except via a survey of stated preferences.
Energy & Resource Conservation	The value of reduced consumption of non-renewable resources is measurable as the cost savings to society and consumers.
Environmental Quality	The traditional approach is to assign monetary values to the reduction in health risks associated with transportation improvements.

The United States Office of Management and Budget recommends considering performance measure monetization from multiple perspectives.[43] For example, the benefits of the presence of positive effects should be quantified, as should the benefits of the absence of negative effects. In addition, active impacts are more easily quantifiable than passive impacts (such as a public park that one can see and use versus air pollution that may or may not be visible), but not necessarily more important, so they should be considered commensurate with their ultimate value.

Because of the complexity that would be involved in monetizing the impacts of transportation corridor design features, due to the need to debate and come to agreement on a whole host of

[42] ibid,. 9.
[43] Office of Management and Budget. (2003). *Circular A-4*. Retrieved March 4, 2009. from www.whitehouse.gov/omb/circulars/a004/a-4.pdf.

values related to both direct and indirect impacts, monetization has not been included in the proposed performance measure framework developed in this research project.

Scoring System

An alternative to monetization is creating a scoring system that organizations can use to rank projects. This system tends to work when the organization is clear about its hierarchy of values and how each direct and indirect effect fit into the hierarchy, therefore precluding the need for monetization.

One example of such a system is the Eastman Kodak Safety Performance Index.[44] The company develops a performance matrix with the goals and range of performance (on a scale of 1-10) for several metrics. The components are ordered in terms of importance and then weighted against one another. Each metric has a baseline, a goal the company expects to meet, and a "stretch goal" that could be attained with excellent performance. Values are determined for each baseline, goal, and stretch goal per metric (such as number of unplanned shutdowns). Actual values are then filled in and multiplied against the weight to find the "score" of each matrix. In this way, the company can monitor its progress, but the origins of the goals are based on an established hierarchy, which can include, but is not automatically linked to, monetization.

The researchers considered incorporating a scoring system into the proposed performance measurement framework developed for urban arterials. However, this approach was discarded in favor of developing an approach more consistent with the current system of performance measurement used by Caltrans.

Using the Information Generated by Performance Measurement

Performance information can be used in multiple ways, such as to:

- Guide resource allocation decisions,
- Aid employee and management evaluations,
- Define gaps between goals and reality,

[44] Department of Energy, *How to Measure Performance: A Handbook of Techniques and Tools*. Retrieved April 5, 2009, from http://www.orau.gov/pbm/handbook/ , Section 1.

- Drive reengineering,
- Aid benchmarking,
- Improve organizational processes,
- Adjust goals, and
- Improve measures.[45]

The researchers intend that Caltrans use the proposed *Complete, Green Streets Performance Measurement Framework* developed for this project in all these ways.

Best Performance Measurement Practices for Complete Streets

In order to supplement Caltrans' current performance measures with measures that are both practical and progressive, the researchers reviewed various performance measurement frameworks used by other state DOTs. Of these, several performance measures stood out with regard to monitoring progress toward implementing Complete Streets principles. In particular, the states of Oregon, Vermont, and Washington seem to have made tremendous effort to provide performance measurement for pedestrians and bicyclists. Performance measures from Florida have been included, as well, for their treatment of travelers, rather than vehicles.

Oregon Department of Transportation

The Oregon Department of Transportation (ODOT) uses a performance measures framework similar to Caltrans, but it is based on a more holistic mission statement and contains performance measures that are notably more concerned with non-motorized vehicle travel and quality of life issues.[46] ODOT's mission is: "*To provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians*." To manage its progress toward this mission, ODOT currently uses a system of 27 "key performance measures", of which six are particularly notable as pertaining to complete streets principles. These six measures are listed below, along with some analysis of them.

[45] United States Government. (1997). *Serving the American Public: Best Practices in Performance Measurement*. Washington, D.C., 20-21.
[46] *Annual Performance Progress Report - Fiscal Year 2006-07*. (2007). Salem, OR: Oregon Department of Transportation.

1. Goal: Improve Travel Safety in Oregon
   Performance Measure: **Traffic injuries per 100 million Vehicle Miles Traveled (VMT)**

Although this measure groups all modes together (as does ODOT's fatality measure), measuring injuries as well as fatalities gives a more accurate picture of overall traffic safety than just measuring fatalities alone. ODOT's strategies for reducing both injuries and fatalities include providing highway safety improvements such as pedestrian crossings, and running educational campaigns targeting driver behavior.

2. Goal: Improve Travel Safety in Oregon
   Performance Measure: **Percent of public satisfied with transportation safety**

This measure is still geared toward motor vehicle travelers, but represents a step in the right direction by attempting to assess perceptions of safety. This is important for non-motorized modes because perceptions affect mode choice. ODOT's strategies for increasing perceptions of safety include educational campaigns that support safe travel behavior.

3. Goal: Move People and Goods Efficiently
   Performance Measure: **Hours of Travel Delay per capita per year in urban areas**

This measure is notable for measuring person delay, rather than vehicle delay. ODOT's strategies to reduce delay include encouraging travel by other modes through the improvement of existing facilities and creation of new opportunities, and promoting the use of "energy efficient transportation alternatives" in order to preserve the environment.

4. Goal: Move People and Goods Efficiently
   Performance Measure: **Percent of Oregonians who commute to work during peak hours by means other than Single Occupancy Vehicle**

Similar to above, ODOT attempts to promote the use of other transportation options through the improvement of existing facilities and creation of transportation alternatives where possible.

5. Goal: Provide a transportation system that supports livability and economic prosperity in Oregon
   Performance Measure: **Percent of urban state highway miles with bike lanes and sidewalks in "fair" or better condition**

This measure is the most specific with regard to pedestrian and bicycle consideration, and represents a clear commitment to providing such facilities on the part of ODOT. It was used as the base for one of the proposed new Stewardship measures described in Chapter IV.

Vermont Department of Transportation

The Vermont Department of Transportation (VTrans) has also specifically targeted improvements for pedestrians and bicyclists in its annual progress report. The improvements are based on the goals of the 2008 Vermont Pedestrian and Bicycle Policy Plan (VPBPP), which has the following vision:[47]

> The State of Vermont has safe, well used, convenient and accessible conditions for bicyclists and pedestrians of all ages and abilities. Bicycle, pedestrian and roadway networks provide mobility throughout the State and links with other transportation modes, while complementing Vermont's natural environment, community character, and overall quality of life.

The VPBPP lists six overarching goals for enhancing Vermont's pedestrian and bicycle system, each of which is supported by one or more of 12 objectives. These objectives provide a framework to guide the agencies and organizations involved in meeting the goals, and are, in turn, measured by 10 overlapping performance measures. Unlike ODOT's performance measures, the VPBPP does not contain specific measures and objectives singularly tied to each other or to specific goals; rather, VTrans sees many of the performance measures as being applicable to several of its goals, and views the process as an integrated effort that benefits from

[47] Wilbur Smith Associates & Toole Design Group. (2008). *Vermont Pedestrian and Bicycle Policy Plan*. Montpelier, VT: Vermont Agency of Transportation.

the measures working together.

The VPBPP's goals and their related performance measures are listed below. The VPBPP specifically states that there is no hierarchy among the goals. (Asterisks signify a new data source is required.)

1. Goal: Cultural Environment. Enhance the human scale and livability of Vermont's communities by improving opportunities for pedestrian and bicycle mobility and access in and between towns, downtowns, villages and rural landscapes.

   Related Performance Measures:
   5. **Miles of sidewalk on State-owned roadways.***
   6. **Miles of shared-use paths.***

2. Goal: Economic Vitality. Enhance the economic vitality of Vermont by increasing economic development opportunities (e.g., create small businesses catering to pedestrian and bicycle needs, making commercial districts more attractive and accessible), providing greater transportation efficiency and choice, improving tourism activities, reducing health costs, and limiting the overall demand on the transportation infrastructure that would result from better pedestrian and bicycle transportation options.

   Related Performance Measures:
   1. **Number of minutes per day the average Vermont resident spends doing pedestrian and bicycle activity.**
   2. **Change in percent of all workers who commute to work by walking or bicycling.***
   3. **Number of pedestrians and bicyclists observed in different parts of Vermont.***

3. Goal: Health. Improve the health of Vermonters and reduce health care costs by making it easier, safer and more convenient for citizens to be more physically active by walking and bicycling on a regular basis.

   Related Performance Measures:
   1. **Number of minutes per day the average Vermont resident spends doing pedestrian and bicycle activity.**
   2. **Change in percent of all workers who commute to work by walking or bicycling.***
   3. **Number of pedestrians and bicyclists observed in different parts of Vermont.***
   9. **Increase in walking and bicycle to and from school for schools participating in Safe Routes to Schools programs.***

4. Goal: Natural Environment. Improve air quality, reduce greenhouse gas emissions which contribute to climate change, increase energy conservation and reduce vehicle miles traveled per capita by increasing the number of trips made by pedestrians and bicyclists.

   Related Performance Measures:
   1. **Number of minutes per day the average Vermont resident spends doing pedestrian and bicycle activity.**
   2. **Change in percent of all workers who commute to work by walking or bicycling.***
   3. **Number of pedestrians and bicyclists observed in different parts of Vermont.***
   9. **Increase in walking and bicycle to and from school for schools participating in Safe Routes to Schools programs.***

5. Goal: Safety. Improve the safety of pedestrian and bicycle travel throughout the entire roadway network, and the accessibility of accessible pedestrian facilities, shared use path, and rail-trail network in Vermont through education and physical improvements.

   Related Performance Measure:
   4. **Police-reported pedestrian and bicycle crashes per number of minutes spent walking and bicycling.***

6. Goal: Transportation Choice. Enhance pedestrian and bicycle transportation options in Vermont so that citizens, regardless of location socioeconomic status, or health can choose a seamless, convenient and comfortable mode that meets their needs. Promote a transportation network, including roadways, shared use paths, rail trails, rails with trails, and accessible pedestrian facilities, that allow pedestrians and bicyclists to reach their destinations throughout the State or to connect to other modes of travel.

   Related Performance Measures:
   5. **Miles of sidewalk on State-owned roadways.***
   6. **Miles of shared-use paths.***
   8. **Total number of VTrans staff and consultants (including regional planning commissions) and local officials who participate in scheduled training sessions on pedestrian and bicycle accommodation and design.**
   10. **Number of schools and students participating in pedestrian or bicycle safety education programs or events (e.g., Safe Routes to School, Bike Smart, etc.).***

Applicable to all goals:
   7. **Total number of VTrans funded bicycle and pedestrian projects and new facilities.**

The VPBPP's objectives are listed below. These serve as the pathways through which the goals will be accomplished, and are related as a group to the set of performance measures listed above. Again, there is no hierarchy among the objectives.

1. As appropriate and feasible, incorporate pedestrian and bicycle transportation needs in VTrans-funded projects and programs.

2. Build and maintain the ability and expertise within all VTrans Divisions to address pedestrian and bicycle needs and issues.

3. Provide pedestrian and bicycle planning, technical, educational, and financial assistance to local governments, regional planning organizations, and other State agencies.

4. Fund planning, design, construction and maintenance of pedestrian and bicycle projects and programs at an adequate level.

5. Maintain on- and off-road pedestrian and bicycle facilities in good operating condition for their expected use.

6. Educate motorists, pedestrians, and bicyclists regarding their shared responsibility to obey the law and engage in safe operating behavior.

7. Encourage more Vermonters to walk and bicycle through programs and promotions.

8. Work with citizens, municipalities, regional planning organizations, and other State agencies to develop, plan, and implement pedestrian and bicycle plans, projects, and programs.

9. Develop and apply measures to track progress toward implementing this Plan.

10. Assess the economic benefits (e.g., small business and community development, transportation efficiency and choice, tourism, and health) and the environmental and cultural benefits (e.g., clean air, clean water, energy efficiency and enhanced community character) of walking and bicycling in Vermont.

11. Promote land use and development principles throughout Vermont that make pedestrian and bicycle travel more convenient.

12. Provide a seamless transportation network for pedestrians and bicyclists by improving linkages between walking, bicycling and other modes of transportation.

Washington Department of Transportation

The Washington Department of Transportation (WSDOT) has set a goal of "*reducing the number of bicyclists killed or injured in traffic crashes by 5% each year, while doubling the percentage of trips made by bicycle within the next 20 years."*[48] To monitor progress toward these goals, WSDOT annually measures:

- **Pedestrian crash rate per 100,000 people;**
- **Total number of pedestrian crashes;**
- **Bicycle crash rate per 1,000,000 people; and**
- **Total number of bicycle crashes.**

The state also keeps track of where the crashes occur, such as the type of roadway and where in the roadway, and the type of driver behavior involved in the crash.

Florida Department of Transportation

The Florida Department of Transportation (FLDOT) focused on the mobility of the traveler – measured as "the quantity of travel served, quality of travel, accessibility, and use of transportation systems" – as its key performance measure for "supporting investment decisions and policy analysis.[49] The following measures pertaining to non-motorized transportation can be found in its planning document, *The Florida Reliability Method*. Although these measures could be more specific, they represent a step in the direction of Complete Streets by examining person travel as opposed to vehicle travel, and by looking specifically at non-motorized accommodation.

Some example measures for each include the following:

- Quantity:
  - **Person miles traveled**
  - **Person trips**

- Quality:

[48] Washington State Department of Transportation. (2009). *The Gray Notebook*. Olympia, WA: Washington State Department of Transportation, 8-9.
[49] Peyrebrune, H. L. (2000). *Performance Measures to Improve Transportation Systems and Agency Operations: Report of a Conference.* Paper presented at the Conference on Performance Measures to Improve Transportation Systems and Agency Operations, Irvine, California. 120-121.

  - **Average speed weighted by person miles traveled**
  - **Average door-to-door travel time**
  - **Reliability (variance of average travel time or speed)**

- Accessibility:
  - **Connectivity to intermodal facilities (percentage within 5 mi)**
  - **Dwelling unit proximity**
  - **Employment proximity**
  - **Percentage of miles of bicycle accommodation in right-of-way**
  - **Percentage of miles of sidewalk coverage**

Best Performance Measurement Practices for Green Streets

Within even the best performance measure frameworks used by state transportation agencies, there is a notable lack of performance measures directed at achieving greener, more permeable and environmentally-benign streets. In fact, according to a recent index of state transportation performance measure reports, it does not appear that any states conduct performance measurement related to tree plantings, landscaping, or permeability.[50] The only adopted measure that relates to Green Streets principles is WSDOT's measure of the cumulative number of WSDOT stormwater treatment facilities constructed or retrofitted annually.[51]

The "best practice" performance measures described above influenced the development of the proposed new performance measures for Caltrans urban arterials, presented in Chapter IV, but the ideas and approaches were adapted to fit within the structure of Caltrans' current performance measurement system. Before that chapter, we turn next to the policies and legislation relevant for creating new performance measures for the Caltrans highway system.

[50] Washington State Department of Transportation, (2009), Performance Measure Library. Retrieved on July 7, 2009, from http://www.wsdot.wa.gov/Accountability/Publications/Library.htm
[51] ibid., 39-41.

CHAPTER III: POLICIES AND LEGISLATION RELEVANT FOR CREATING NEW PERFORMANCE MEASURES FOR CALIFORNIA STATE TRANSPORTATION

As explained in the Introduction, Caltrans' current framework of objectives and performance measures reflects priorities established in its Strategic Plan, but none of the objectives and measures deal directly with non-motorized transportation or the mitigation of the adverse local environmental impacts of transportation corridors. This situation is problematic because the agency is subject to a number of legislative mandates, policies, and directives regarding non-motorized safety and mobility and environmental quality at the federal, state, and agency levels.

In order to help Caltrans be accountable to these mandates and policies, new agency objectives and performance measures are needed to supplement those Caltrans already uses. This chapter first outlines the various policies and mandates to which Caltrans is subject, then examines Caltrans' current objectives and performance measures and analyzes how elements of the various mandates and policies are not presently represented. It concludes with strategies for representing these elements through the proposed objectives and performance measures for urban arterials described in Chapter IV.

Plans, Policies, Goals and Legislation Affecting Caltrans

Caltrans is subject to numerous plans, goals, policies, and pieces of legislation enacted at both federal and state levels of government, as well as internal plans and mandates generated by the agency itself. Nationally, federal transportation legislation and the Federal Highway Administration (FHWA) have set targets for non-motorized transportation, and the Environmental Protection Agency (EPA) is considering targets for both greenhouse gas emissions reductions and green streets. At the State level, Governor Arnold Schwarzenegger has signed several pieces of legislation intended to push the state toward more sustainable transportation planning. Within Caltrans itself, long-range plans and directives such as *DD-64-R1: Complete Streets* indicate that the agency is moving toward a more holistic transportation

vision. The most relevant of these plans, goals, policies, pieces of legislation, and internal mandates are described in the sections that follow.

National

In the last two decades, the United States Department of Transportation (US DOT) and the Federal Highway Administration (FHWA) have begun to more formally recognize the role of non-motorized transportation in providing sustainable mobility. Beginning with the passage of the *Intermodal Surface Transportation Efficiency Act* (ISTEA) in 1991, the federal government began to see the benefits of promoting bicycling and walking as modes of transportation. When the *Transportation Equity Act for the 21st Century* (TEA-21) was authorized in 1998, the goals were reiterated and the amount of funding allocated to pedestrian and bicycle planning increased. The passage of the *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* (SAFETEA-LU) in 2005 again affirmed this commitment and provided even more resources for non-motorized modes, emphasizing Safe Routes to School as a national strategy to encourage walking and bicycling for children. The upcoming surface transportation program reauthorization, scheduled for 2009, is expected to focus on sustainability and even more strongly support non-motorized transportation as a part of the national transportation strategy.

Legislation

SAFETEA-LU (2005)

Previous versions of transportation legislation have been subsumed into SAFETEA-LU, which continued the commitment that non-motorized users should be considered during the planning, development, and construction of all federally funded transportation projects and programs. SAFETEA-LU includes the following statements regarding pedestrian and bicycle transportation:[52]

> (Long-range metropolitan and state transportation plans and Transportation Improvement Programs shall) provide for the development and integrated management and operation

[52] Federal Highway Administration. (2008). FHWA Guidance - Bicycle and Pedestrian Provisions of Federal Transportation Legislation. *Bicycle & Pedestrian*. Retrieved April 24, 2009, from http://www.fhwa.dot.gov/environment/bikeped/bp-guid.htm

> of transportation facilities (including accessible pedestrian walkways and bicycle transportation facilities) that will function as an intermodal transportation system... (23 U.S.C 134(c)(2) and 135(a)(2))
>
> Bicyclists and pedestrians shall be given due consideration in the comprehensive transportation plans developed by each metropolitan planning organization and State... (23 U.S.C. 217(g)(1))
>
> Bicycle transportation facilities and pedestrian walkways shall be considered, where appropriate, in conjunction with all new construction and reconstruction and transportation facilities, except where bicycle and pedestrian use are not permitted. (23 U.S.C. 217(g)(1))
>
> Transportation plans and projects shall provide due consideration for safety and contiguous routes for bicyclists and pedestrians. (23 U.S.C. 217(g)(2))

Following is the conclusion of the FHWA on the intent of SAFETEA-LU to provide for pedestrian and bicycle transportation moving forward:[53]

> While these sections stop short of requiring specific bicycle and pedestrian accommodation in every transportation project, **Congress clearly intends for bicyclists and pedestrians to have safe, convenient access to the transportation system** and sees every transportation improvement as an opportunity to enhance the safety and convenience of the two modes. **"Due consideration" of bicycle and pedestrian needs should include, at a minimum, a presumption that bicyclists and pedestrians will be accommodated in the design of new and improved transportation facilities. In the planning, design, and operation of transportation facilities, bicyclists and pedestrians should be included as a matter of routine**, and the decision to not accommodate them should be the exception rather than the rule. There must be exceptional circumstances for denying bicycle and pedestrian access either by prohibition or by designing highways that are incompatible with safe, convenient walking and bicycling.
>
> …Even where circumstances are exceptional and bicycle use and walking are either prohibited or made incompatible, States, MPOs, and local governments must still ensure that bicycle and pedestrian access along the corridor served by the new or improved facility is not made more difficult or impossible.

American Reinvestment and Recovery Act (2009)

The dire economic circumstances of 2009 led President Obama and Congress to attempt to spur the economy through a massive, $780 billion spending bill known as the American Reinvestment

[53] Federal Highway Administration. (2008), 2 (Emphasis added).

and Recovery Act. Secretary of Transportation LaHood, a vocal supporter of non-motorized travel as part of the transportation system, explained the commitment of the Stimulus Package to non-motorized transportation:[54]

> Bicycling was one of the earliest beneficiaries of stimulus funding, with portions of the American Reinvestment and Recovery Act explicitly devoted to bicycling, and this department has been very active in getting that funding out the door. **States must spend 3 percent of their allocation on the Transportation Enhancements program, which is a primary source of bicycle and pedestrian infrastructure funding. The remainder of the "highway" money also creates an opportunity to build complete streets. All of the highway funding is flexible, and bicycle and pedestrian projects are eligible. The 3 percent in Transportation Enhancements is a floor not a ceiling.** 30 percent of a state's allocation is sub-allocated to urbanized areas, where commuting by bicycle is most likely.

Other parts of the Act are also flexible and can be used to support pedestrian and bicycle transportation.

Policies

National Bicycling and Walking Study (1994)

Prior to the passage of ISTEA in 1991, the US DOT adopted a national transportation policy that sought to "increase use of bicycling, and encourage planners and engineers to accommodate bicycle and pedestrian needs in designing transportation facilities…"[55] Seeking to understand how the US DOT planned to accomplish these goals, the US Congress commissioned the National Bicycling and Walking Study (NBWS) to investigate the challenges to promoting non-motorized transportation. The NBWS was produced by the US DOT and represents the first time in history that the federal government committed itself to reaching certain targets for modeshares. Two overall goals emerged from the NBWS:

1. Double the percentage of total trips made by bicycling and walking in the United States from 7.9 percent to 15.8 percent of all travel trips; and

[54] Secretary of Transportation LaHood. (2009). Bicycling is an important factor in less carbon-intensive commuting. *Welcome to the Fast Lane: The Official Blog of the U.S. Secretary of Transportation* Retrieved April 27, 2009 (Emphasis added).
[55] Federal Highway Administration. (2004). National Bicycling and Walking Study Ten Year Status Report by the U.S. Department of Transportation. *Bicycle & Pedestrian*. Retrieved April 30, 2009, from http://www.fhwa.dot.gov/environment/bikeped/study/index.htm

2. Simultaneously reduce by 10 percent the number of bicyclists and pedestrians killed or injured in traffic crashes.

Although the goal of reducing fatalities and injuries by 10% has been surpassed, the goal of doubling trips has remained elusive, with little progress made.

Accommodating Bicycle and Pedestrian Travel (1999)

This US DOT policy statement was written to guide the process of "Integrating Bicycling and Walking into Transportation Infrastructure."[56] Only sections applicable to urban areas are included here.

> 1. Bicycle and pedestrian ways shall be established in new construction and reconstruction projects in all urbanized areas unless bicyclists and pedestrians are prohibited by law from using the roadway, the cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use, or scarcity of population or other factors indicate an absence of need. …
>
> 3. Sidewalks, shared use paths, street crossings (including over- and undercrossings), pedestrian signals, signs, street furniture, transit stops and facilities, and all connecting pathways shall be designed, constructed, operated and maintained so that all pedestrians, including people with disabilities, can travel safely and independently.
>
> 4. The design and development of the transportation infrastructure shall improve conditions for bicycling and walking through…planning projects for the long-term,…addressing the need for bicyclists and pedestrians to cross corridors as well as travel along them,…designing facilities to the best currently available standards and guidelines.

The FHWA website on design guidance continues by saying:[57]

> There is no question that conditions for bicycling and walking need to be improved in every community in the United States; it is no longer acceptable that 6,000 bicyclists and pedestrians are killed in traffic every year, that people with disabilities cannot travel without encountering barriers, and that two desirable and efficient modes of travel have been made difficult and uncomfortable.

[56] Federal Highway Administration. (1999). Design Guidance Accommodating Bicycle and Pedestrian Travel: A Recommended Approach. *Bicycle & Pedestrian*. Retrieved April 30, 2009, from http://www.fhwa.dot.gov/environment/bikeped/design.htm (Emphasis added)
[57] ibid., Conclusion.

> Every transportation agency has the responsibility and the opportunity to make a difference to the bicycle-friendliness and walkability of our communities. The design information to accommodate bicyclists and pedestrians is available, as is the funding. **The United States Department of Transportation is committed to doing all it can to improve conditions for bicycling and walking and to make them safer ways to travel.**

EPA Green Infrastructure Statement of Intent (2007)

Regarding the movement toward building Green Streets, the EPA continues to develop the field through research, publications, trainings and pilot projects on Green Infrastructure projects. In 2007, the EPA and several partner agencies signed a Statement of Intent to collaborate and build support for green infrastructure projects.[58] Among the objectives of the Statement were:

> Develop strategies to promote the use of green infrastructure by cities and utilities as an effective and feasible means of reducing stormwater pollution and sewer overflows by:
> - Developing models for all components of green infrastructure and mak(ing) them available nationwide;
> - Providing technical assistance, training, and outreach to potential users of green infrastructure, including states, cities, counties, utilities, environmental and public health agencies, engineers, architects, landscape architects, planners and nongovernmental organizations;
> - Establishing a web-based green infrastructure resource center at EPA to assist communities in complying with requirements for combined sewer overflows and municipal stormwater permits and evaluating the multiple environmental benefits that green infrastructure can provide; and
> - Developing tools to assist local green infrastructure programs with outreach, training, model development and application, planning and design, monitoring, and plan review.

State of California

California has its own goals for non-motorized users and energy and emissions reductions. These goals fit well with and are often even more aggressive than the goals set by the federal government. This provides the opportunity for California to lead other states by example with regard to promoting bicycling and walking and reducing the environmental impact of local transportation. These goals also provide the possibility of taxpayers holding the state

[58] Environmental Protection Agency. (2007). *Green Infrastructure Statement of Intent*. Retrieved May 20, 2009. from http://www.cleanwateramericaalliance.org/reports/gc/2007-04-19_epa_si.pdf

accountable for its actions and progress toward the goals – something the proposed performance measures may enable.

Statewide Plans

California Blueprint for Cycling and Walking (2002)

Published in 2002, the Blueprint was Caltrans' response to the Budget Act's requirement to address "measurable goals for increasing bicycling and walking within the state, funding of facilities, and a reduction in pedestrian and bicycling injuries and fatalities."[59] The report stated ambitious goals:

- A **50 percent increase in the number of bicycling and walking trips by the year 2010** (compared to base year 2000 levels as measured by the US Census)
- A **50 percent decrease in the bicycle and pedestrian fatality rates by the year 2010** (compared to base year 2000 levels as measured by the NHTSA)
- Increased funding for bicycle and pedestrian programs as necessary to meet these goals

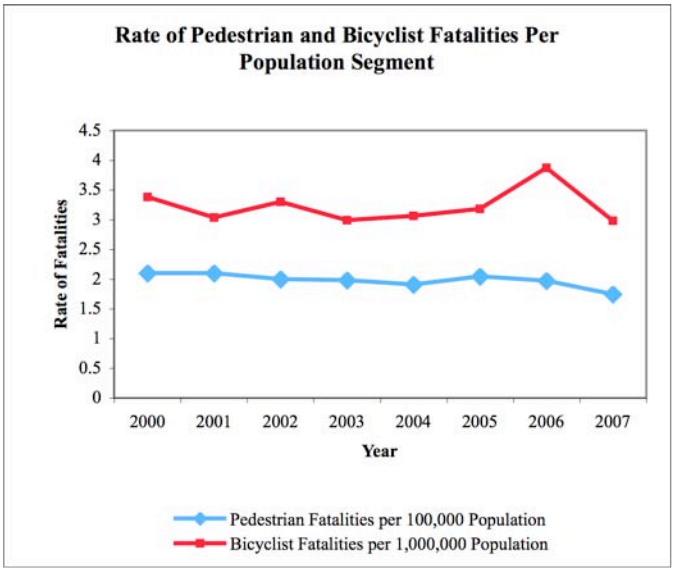
As the 2010 Census has not yet been conducted, how close California has come to doubling the number of number of trips from the baseline of 0.83% bicycle and 2.85% pedestrian commute trips cannot be exactly determined.[60] However, data from the American Community Survey from 2007, also administered by the U.S. Census Bureau, may be used as a proxy. The ACS data indicates that California's rate of bicycle commuting as of 2007 had barely increased to 0.9% (although the margin of error was +/-0.1), and walking to work had remained approximately 2.8%.[61] This lack of overall progress in non-motorized commute trends in California suggests that the trip goals of the Blueprint will be almost impossible to meet.

Data for safety is measured more frequently, and trends are therefore more easily determined. Figures 1 and 2 illustrate the only slightly negative overall trend in traffic fatalities in California

[59] Caltrans. California Blueprint for Walking and Bicycling. May 2002 Retrieved on October 2, 2008 from www.dot.ca.gov/hq/tpp/offices/bike/sites_files/CABlueprintRpt.pdf
[60] U.S. Census Bureau. (2000). Means of transportation to Work for Workers 16 Years and Over. In C. S. F. S.-S. Data (Ed.), *American Factfinder*. Washington, D.C.: U.S. Census Bureau, 30.
[61] U.S. Census Bureau. (2007). *California S0801: Commuting Characteristics by Sex*. Washington, D.C.: U.S. Census Bureau.

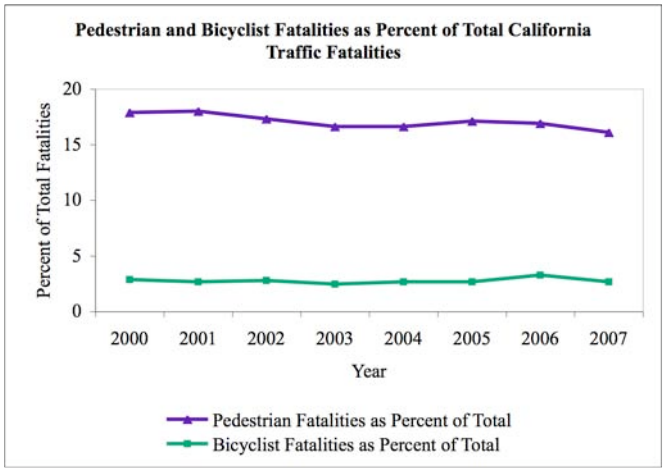
from 2000 to 2007 – clearly not yet to the goal of halving the rates of fatalities.[62] Although the data for 2008 is not yet available, the trends suggest that the numbers will not be very different, and that the goal for safety, like the goal for increasing trips, will go unmet.

Figure 1: Rate of Pedestrian and Bicyclist Fatalities in California per Population Amount (2000-2007)



Data Source: National Highway Traffic Safety Administration

Figure 2: Pedestrian and Bicyclist Fatalities as Percent of Total California Traffic Fatalities (2000-2007)



Data Source: National Highway Traffic Safety Administration

[62] National Highway Traffic Safety Association. (2000-2007). *Traffic Safety Facts – 2000-2007 Data for Pedestrians*. Washington, DC.
National Highway Traffic Safety Association. (2000-2007). *Traffic Safety Facts – 2000-2007 Data for Bicyclists*. Washington, DC.

California Transportation Plans 2025 (2006) and 2030 (2007)

The California Transportation Plan 2030 (CTP) is an update to California's long-range transportation plan, CTP 2025. Both were developed in conjunction with Caltrans by the Office of State Planning, and seek to "influence transportation decisions and investments to create a world-class transportation system."[63] As the basis for Governor Schwarzenegger's *GoCalifornia* plan, which aims to spur a reduction in congestion and improvements in mobility, the CTP documents outline a broad-level approach to the future of transportation in California, summed in its sweeping vision:

> California has a safe, sustainable, world-class transportation system that provides for the mobility and accessibility of people, goods, services, and information through an integrated, multimodal network that is developed through collaboration and achieves a Prosperous Economy, a Quality Environment, and Social Equity.[64]

The CTP speaks candidly about the need to improve non-motorized mobility and preserve the natural environment in order to achieve a more sustainable transportation system:

> Mobility is not mode-specific; rather it encompasses **all modes**. We need to choose transportation investments that will **provide the greatest mobility and efficient use of the entire system**. … A sustainable transportation system is one that **meets people's needs equitably**, fosters a **healthy environment**, provides a broad, balanced system in which the private vehicle, **public transportation, bicycling, and walking are all viable options** and can be maintained and operated efficiently and effectively over time.[65]
>
> In recent years, the number of non-work trips has overtaken the number of commute trips…the increase…can be partially attributed to the need to drive to most destinations, due to changes in urban and street design, and **lack of safe, convenient travel choices**.[66]
>
> A major focus of SAFETEA-LU and of the CTP 2030 Addendum is the **linking of transportation planning with natural resource and environmental planning** to promote early consultation. … **The goal of this early consultation is transportation plans, and ultimately projects, that preserve and enhance California's valuable natural and environmental resources**.[67]

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[63] Smith, N., Korte, P., & Henriquez, R. (2006). *California Transportation Plan 2025*. Retrieved March 20, 2009. from http://www.dot.ca.gov/hq/tpp/offices/osp/ctp2025.html
[64] ibid, Cover page.
[65] ibid, iii (Emphasis added).
[66] ibid., vii.
[67] California Department of Transportation. (2007). California Transportation Plan 2030 Addendum. Retrieved March 25, 2009, from http://www.dot.ca.gov/hq/tpp/offices/osp/ctp2030.html (Emphasis added)

These statements seem to indicate a need to shift investment from the private auto into pedestrian and bicycling facilities and public transportation. The CTP developed several goals and strategies for achieving a sustainable transportation system. The goals applicable to the proposed performance measures presented in this paper follow below.

Goal 1) Improve Mobility and Accessibility

Policy: *Manage and operate an efficient intermodal transportation system*[68]

Strategies: Enhance connectivity between transportation modes.

- Enhance system connectivity and convenience between motorized and nonmotorized transportation modes.
- Include infrastructure to support non-motorized modes during the planning and design phases of project development.

Support systems for comprehensive multimodal planning and system performance analysis that incorporate all transportation modes.

- Accelerate deployment of data collection technologies and communications.
- Improve analytical methods for assessing performance data.

Policy: *Provide viable transportation choices*[69]

Strategies: Establish methods for evaluating levels of service for all modes in support of an integrated, multimodal transportation system.

Support the goals and further the efforts initiated by the *California Blueprint for Cycling and Walking*

- Integrate bicycling into mainstream transportation models and modeling, including cost benefit analysis of bicycle facilities.
- Remove barriers to walking and bicycling.
- Educate California's youth on the health and air quality benefits of making trips by bicycle or foot.

Policy: *Support research to advance safe and environmentally responsible mobility and accessibility*[70]

Strategy: Continue to enhance the understanding of road ecology, a field of study that seeks to explain the relationship between roads and the natural environment.

[68] Smith, N., Korte, P., & Henriquez, R. (2006). *California Transportation Plan 2025*, 34-37.
[69] ibid., 39-41.
[70] ibid., 41-42.

Goal 4) Enhance Public Safety and Security

Policy: *Improve system and user safety*[71]

Strategies: Increase education and outreach programs that address safe transportation behavior, including drivers training, awareness of pedestrian and bicyclists, safe biking practices, and truck driver training.

- Include safe pedestrian and bicycle facilities in the design of new or upgraded roadways.

Increase patrols to enforce speed restrictions, minimize aggressive driver behavior, and driving under the influence of alcohol…

Improve transportation system safety for older Californians.

- Establish roadway infrastructure and land use practices that promote safety.

Goal 5) Reflect Community Values

Policy: *Manage growth*[72]

Strategy: Provide incentives to promote sustainable land use decisions that integrate land use, housing, and transportation through General Plans, regional transportation plans, and interregional cooperation.

- Increase densities and designs strategically to facilitate effective transit service, including encouraging transit-oriented development within major transit corridors and providing the ability to conveniently walk to destinations.
- Promote street and urban design to encourage walking and bicycling to destinations.
- Incorporate community values and support context sensitive solutions for all transportation facilities and infrastructure.

Goal 6) Enhance the Environment

Policy: *Conserve natural resources*[73]

Strategies: Develop or amend transportation planning tools to include land use impacts, demand management, efficient use of energy, and modal alternative analysis.

Continue to avoid and minimize impacts to the greatest extent possible.

Continue building conservation banking partnerships to protect ecosystems and preserve large contiguous and viable tracts of habitat to offset adverse impacts, and determine the most valuable land for banking.

[71] Smith, N et. al. (2008), 50-52.
[72] ibid., 54-64.
[73] ibid., 60-61.

- Promote a greater understanding of the relationship between the natural environment and transportation.
- Develop better tools to model cumulative impacts to the environment and wildlife.
- Minimize impermeable surfaces and install facilities to capture stormwater runoff.

Policy: *Commit to a clean and energy efficient system*[74]

Strategy: Enhance education, planning tools, and performance standards on energy efficiency, air quality, and climate implications of transportation decision-making.

- Analyze the cost-effectiveness of transportation options that improve energy efficiency and reduce emissions of GHGs and criteria air pollutants.
- Develop tools that improve data collection, analysis, and modeling capabilities for State and local development planning and projects.

Legislation

The State Legislature has passed several pieces of legislation pertaining to various aspects of transportation in California. Each of these bills mandates or encourages provision for non-motorized users on California's streets.

AB 1358 Complete Streets (2008)

As explained in the Introduction, the Complete Streets Act of California was signed into law in September of 2008, following the lead of several other states that had established Complete Streets policies.[75] The Act went into effect on January 1, 2009, and

> …requires the legislative body of a city or county, upon revision of the circulation element of their general plan, to **identify how the jurisdiction will provide for the routine accommodation of all users of the roadway** including motorists, pedestrians, bicyclists, individuals with disabilities, seniors, and users of public transportation.[76]

The principles of Complete Streets underlie many of the proposed performance measures in Chapter IV.

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[74] Smith, N et. al. (2008), 61, 64.
[75] California Bicycle Coalition. (2008). AB 1358, The Complete Streets Act. *Current Legislation* Retrieved April 30, 2009, from http://www.calbike.org/legislation.htm#AB1358
[76] Assemblyman Mark Leno. (2007). *The Complete Streets Act Fact Sheet*. Retrieved May 23, 2009. from http://www.calbike.org/pdfs/AB1358_Fact_Sheet.pdf (Emphasis added)

AB 32: The Global Warming Solutions Act (2006)

Assembly Bill 32 is known as the "Global Warming Solutions Act" because it aims to curb the amount of greenhouse gases emitted into the atmosphere in California. The bill set an ambitious target for reducing the amount of greenhouse gases: by 2020, the emissions should be at 1990 levels. The long-term goal is an 80% reduction of 1990 levels by 2050. According to the California Air Resources Board, which is the lead agency for implementing the legislation, this amounts to an approximately 15% reduction from current levels of emissions, or about 4 fewer tons of carbon dioxide emitted per person in the state (approximately 147,000,000 tons of CO_2).[77] Understandably, broad actions are focused on making the state's heavy and light duty vehicles and power plants cleaner. However, making non-motorized transportation a viable option for short trips throughout the state's urbanized areas can help achieve these goals in two important ways. First, because automobiles release the majority of their emissions while the engine is warming up (a "cold start"), short automobile trips disproportionately pollute the air in comparison with longer trips;[78] second, short trips in urban areas contribute to the urban heat island effect, necessitating greater energy usage by power plants to keep buildings cool. Substituting transit, bicycling, or walking for short trips in urban areas can therefore actually make a considerable contribution to reducing emissions.

SB 375 Regional Planning for Greenhouse Gas Reduction (2008)

Passed in 2008, Senate Bill 375 is meant to complement AB 32 by seeking to reduce the amount of vehicle miles traveled through a combination of land use and planning incentives.[79] The bill requires regional transportation planning agencies to develop more sophisticated transportation planning models for the purpose of creating "sustainable community strategies (SCS)" that limit greenhouse gas emissions in their regional plans. The bill also provides incentives for local governments to incorporate these SCSs into the transportation elements of their general land use plans. Ultimately, it is likely that the SCSs will promote moderate to dense urban development,

[77] California Air Resources Board. (2008). *Climate Change Scoping Plan*. Sacramento: California Air Resources Board.
[78] Ludykar, D., Westerholm, R., & Almén, J. (1999). Cold start emissions at +22, -7, and -20˚C ambient temperatures from a three-way catalyst (TWC) car: regulated and unregulated exhaust components. *The Science of the Total Environment, 235*, 65-69.
[79] California Bicycle Coalition. (2009). SB 375 (Steinberg), Regional planning for greenhouse gas reduction, travel demand models. *Current Legislation* Retrieved May 5, 2009, from http://www.calbike.org/legislation.htm#SB375

which tend to provide more opportunities to walk and bicycle and will therefore require adequate pedestrian and bicycle facilities to support the travel.

AB 57 Safe Routes to School (2007)

Begun in 1999, the Safe Routes to School (SR2S) legislation in California requires federal safety funds to be allocated equally between state highways, local roads, and the SR2S construction program.[80] The funding for SR2S supports bicycle and pedestrian safety, infrastructure, and traffic calming projects such as sidewalks, bicycle lanes, trails, and intersection improvements. AB 57 served to make the previous funding allocation permanent and created a framework for federal SRTS funding to be included in the state budget.

AB 2971 Fair Share for Safety (2008 – Proposed but not Passed)

Assembly Bill 2971 was intended to require Caltrans to "establish guidance and criteria to ensure that the needs of bicyclists and pedestrians are addressed in the development of its safety programs" by January 1, 2010.[81] In developing this guidance and criteria, Caltrans would have had to consider a variety of factors to ensure it accounted for areas with safety problems so severe that there were no non-motorized injuries or fatalities because there were no non-motorized travelers intrepid enough to take the risk.[82] The bill would also have required Caltrans to consult with stakeholders like the California Bicycle Coalition while developing this guidance and criteria. Although the bill passed the Legislature, Governor Schwarzenegger vetoed the bill due to what he considered redundancy with Caltrans' current authority. However, the expectation remains that Caltrans will address particularly dangerous intersections, underscoring the need for performance measures that can target safety hotspots. Specific measures to address such hotspots are proposed in Chapter IV.

[80] Safe Routes to School National Partnership. (2007). Legislation and Policies. Retrieved April 30, 2009, from http://www.saferoutespartnership.org/state/4373/california#legislation
[81] *Fair Share for Safety*, California Assembly, 2008 Session(2008).
[82] California Bicycle Coalition. (2009). AB 2971, Fair Share for Safety. *Current Legislation* Retrieved May 5, 2009, from http://www.calbike.org/legislation.htm#AB2971

California Department of Transportation

In many of its statements and policies, Caltrans has presented itself as having a holistic vision. Although its Mission is focused solely on mobility, its five high-level goals cover a broad range of topics (*safety, mobility, stewardship, delivery,* and *service*) important to Californians, whether traveling or not. In addition, Caltrans' current Strategic Plan acknowledges the challenges Californians will face as population grows rapidly, the transportation system continues to age, funding is limited, and protecting the environment and the safety of the public while traveling grow increasingly important.[83] Although the equally pertinent challenges of dealing with a rapidly aging population and epidemics of chronic disease are not mentioned, they fit well with Caltrans' goals of increasing mobility. However, there seems to be a disconnect between what is presented through policies and mandates, and what is currently designed, built, and then measured for performance.

Caltrans' current system of performance measurement is structured around the Agency's five goals, each of which is accompanied by a set of objectives with set timeframes and numerical targets. Progress toward each objective is measured by one or more performance measures. Appendix A contains a chart of Caltrans' existing objectives and performance measures. Although they thoroughly address certain aspects of each goal, there is a lack of objectives and measures dealing with non-motorized transportation or the environment. The framework of new objectives and measures proposed in Chapter IV aims to complement Caltrans' current measurement approach and fill the gap for pedestrian and bicycle safety and mobility, as well as environmental stewardship. The proposed objectives and measures should enable Caltrans to gauge its progress toward meeting the broad-level goals and requirements of the Complete Streets mandate and Green Streets criteria.

[83] California Department of Transportation. (2007). *Caltrans Strategic Plan 2007-2012*. Retrieved April 10, 2009. from http://www.dot.ca.gov/docs/StrategicPlan2007-2012.pdf ,10-11.

Policies and Plans

Caltrans has developed numerous planning documents and issued several policy statements by which it aims to abide. Those that are the most relevant for guiding the creation of Complete, Green Streets objectives and performance measures are profiled below.

Caltrans Strategic Plan (2007)

Caltrans' Strategic Plan, which is updated every five years, is the key governing document for the agency, and the agency's performance measurement system is linked to it. The current Strategic Plan states that it "…focuses on strategies which are seen as key for organizational process improvement over the next five years…(and) addresses the key external and internal driving forces that are affecting or have the potential to affect Caltrans mandates."[84] The Strategic Plan elaborates upon how the agency plans to work toward its goals during the years 2007-2012.

Regarding the goal of *safety*, the Strategic Plan describes two efforts pertaining to non-motorized users: the Safe Routes to Schools program and the Strategic Highway Safety Plan (covered below). The goal of *mobility* is described as, among other things, "improving multi-modal connectivity, (and) addressing bicyclist and pedestrian needs…"[85] However, the performance measures regarding non-motorized travelers are weak or non-existent, as will be explained in the following section.

Strategic Highway Safety Plan (2006)

The Strategic Highway Safety Plan (SHSP) aims to improve traffic safety in California in 12 specific areas, based on analysis of California's crash trends and demographics.[86] In recognition of the lack of measures for non-motorized transportation in Caltrans' Strategic Plan, three goals were developed that are particularly applicable for the creation of a *Complete, Green Streets Performance Measurement Framework* for urban arterials:

[84] California Department of Transportation. *Caltrans Strategic Plan 2007-2012*, 5.
[85] ibid., 26.
[86] California Department of Transportation. (2006). *California Strategic Highway Safety Plan Version 2*. Retrieved April 12, 2009. from http://www.dot.ca.gov/hq/traffops/survey/SHSP/SHSP-Booklet-version2_%20PRINT.pdf. , 6.

- Challenge 7: *Improve Intersection and Interchange Safety for Roadway Users*[87]

  Goal: By 2010, reduce the number of intersection crash fatalities by 15 percent from their 2004 level.

  Strategies relevant to the creation of the new performance measurement framework:

  1. Improve the visibility of and at intersections (illumination, marking, and advanced warning).
  2. Improve the design of traffic control devices.
  3. Improve roadway design at intersections.

- Challenge 8: *Make Walking and Street Crossing Safer*[88]

  Goal: By 2010, reduce the number of pedestrian fatalities attributed to vehicle collisions by 25 percent from their 2000 level.[89]

  Strategies relevant to the creation of the new performance measurement framework:

  1. Promote and improve roadway safety infrastructure for pedestrians including the use of advanced technology.
  2. Improve the visibility of pedestrians on the roadway.
  3. Improve the safety of pedestrians traveling to and from schools.
  4. Improve data collection and analysis regarding pedestrian trip characteristics, level of service, injuries and fatalities on California roadways.
  5. Improve pedestrian safety expertise among transportation professionals.
  6. Consider pedestrian needs in all roadway and transit projects.

- Challenge 13: *Improve Bicycling Safety*[90]

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[87] ibid., 24.
[88] ibid., 26-27.
[89] This goal was established in the legislative report *California Blueprint for Bicycling and Walking*, and assumes that the Blueprint's mobility goal of a 50% increase in pedestrian trips by 2010 will also be achieved.
[90] California Department of Transportation. (2006),36.

Goal: by 2010, reduce the number of bicycle roadway fatalities by 25 percent from their 2000 level.[91]

Strategies relevant to the creation of the performance measurement framework:

1. Improve data collection regarding bicyclist trips, injuries, and fatalities on California roadways.
2. Promote and improve roadway safety infrastructure for bicyclist use.
3. Improve the visibility of bicyclists on the roadway.
4. Improve the safety of bicyclists traveling to and from schools, utilizing education, encouragement, enforcement and engineering techniques.
5. Improve bicycle safety expertise among transportation professionals.

Although these strategies would likely contribute to safer, more accessible roadways for pedestrians and bicyclists, the goals themselves actually measure the wrong quantity. Because the goals require numbers of fatalities, they do not account for exposure, meaning that the goal could potentially be met if the overall number of fatalities decreased due to a system-wide decrease in walking and bicycling. The goal itself attempts to address this by its assumption that the Blueprint's goals for increase in modeshare will occur. However, as we have seen, that is extremely unlikely to happen, rendering this measure ineffective. Instead, the goal should be a decrease in the *rate* of walking and bicycling fatalities, which would appropriately account for exposure. The proposed measures in Chapter IV for include rates for both fatalities and injuries for pedestrians and bicyclists.

[91] This goal was established in the legislative report *California Blueprint for Bicycling and Walking*, and assumes that the Blueprint's mobility goal of a 50% increase in bicycling trips by 2010 will also be achieved.

Deputy Directive 64-R1: Complete Streets – Integrating the Transportation System (2008)

The internal Caltrans mandate known as DD-64-R1, briefly described in the Introduction, will be a key policy for Caltrans going forward. It mandates a new Complete Streets attitude for the agency. Key parts of the directive are as follows:[92]

> The California Department of Transportation (Department) provides for the needs of travelers of all ages and abilities in all planning, programming, design, construction, operations, and maintenance activities and products on the State highway system. **The Department views all transportation improvements as opportunities to improve safety, access, and mobility for all travelers in California and recognizes bicycle, pedestrian, and transit modes as integral elements of the transportation system.**
>
> The Department develops integrated multimodal projects in balance with community goals, plans, and values. Addressing the safety and mobility needs of bicyclists, pedestrians, and transit users in all projects, regardless of funding, is implicit in these objectives. **Bicycle, pedestrian, and transit travel is facilitated by creating "complete streets" beginning early in system planning and continuing through project delivery and maintenance and operations.** Developing a network of "complete streets" requires collaboration among all Department functional units and stakeholders to establish effective partnerships.

Context Sensitive Solutions (2001)

Caltrans has also issued a Director's Policy for Context Sensitive Solutions.[93] The policy is meant to give flexibility to communities across California that expect their state highways – particularly when they operate as "main streets" – to do more than just carry traffic. The policy states that:

> The Department uses "Context Sensitive Solutions" as an approach to plan, design, construct, maintain, and operate its transportation system. These solutions use innovative and inclusive approaches that integrate and balance community, aesthetic, historic, and environmental values with transportation safety, maintenance, and performance goals. Context sensitive solutions are reached through a collaborative, interdisciplinary approach involving all stakeholders.
>
> The context of all projects and activities is a key factor in reaching decisions. It is considered for all State transportation and support facilities when defining, developing, and evaluating options. When considering the context, issues such as funding feasibility,

[92] *Complete Streets - Integrating the Transportation System, DD-64-R1 C.F.R.* (2008) (Emphasis added).
[93] California Department of Transportation. (2001). Director's Policy on Context Sensitive Solutions. Sacramento: California Department of Transportation.

maintenance feasibility, traffic demand, impact on alternate routes, impact on safety, and relevant laws, rules, and regulations must be addressed.

Main Streets: Flexibility in Design & Operations (2005)

In keeping with the policy on Context Sensitive Solutions, Caltrans published the Main Streets booklet to help communities create more livable main streets. The booklet states that:

> Caltrans remains committed to the notion that people live, work and play in the communities through which our facilities pass. It is our duty, by recognizing the needs of both non-motorized and motorized modes of transportation, to assure that living space is a good space in which to live. We are committed to full cooperation with the citizens and elected officials of those communities to find transportation solutions that meet both our duty to protect the safety and mobility of travelers, as well as making main streets an integral part of the community.[94]

The Main Street philosophy is to provide a balance of mobility and other values to Caltrans roadway users.[95] These other values may include safety, the ability of a community to achieve goals and objectives, the needs of disadvantaged groups and those with few mobility options, and avoiding or minimizing where possible adverse effects on natural resources. The decision-making process should also include community input, and should keep in mind larger state goals such as the reduction of greenhouse gases in AB-32. The Main Streets document also suggests a series of performance measures intended to "determine and confirm compatibility with community values."[96] The measures relevant to the creation of a new performance measurement framework for Caltrans' urban arterials are as follows:

- Lower motorized operating speeds and improved Level of Service (LOS),
- Improved pedestrian access and mobility,
- Improved access to schools and businesses,
- Improved safety,
- Improved bicycle accessibility and mobility, and
- Protecting and preserving scenic and historic qualities and attributes.

[94] California Department of Transportation. (2005). *Main Streets: Flexibility in Design & Operations*. Sacramento, CA: California Department of Transportation, 1.
[95] ibid., 5.
[96] ibid., 6.

Performance Measures for Rural Transportation Systems Guidebook (2006)

Caltrans published this guidebook on performance measures for rural areas to assist in "measuring roadway-related transportation system performance", a subject area deemed to be missing from the research literature.[97] The guidebook provides strategies for performance measurement for rural transportation systems in the following areas: safety, system preservation, mobility, accessibility, reliability, productivity, and return on investment. The guidebook also signals a need within Caltrans for a complimentary document focusing on urban transportation systems.

Evaluation of Caltrans' Current Objectives and Performance Measures

Although Caltrans' Strategic Plan mentions non-motorized users and stewardship of natural resources, its current framework of objectives and performance measures is not very strong in either regard. This reflects a history of engineering focused on highways and the automobile, which, for a long time, was the clear preference of most of society. However, as society has grown more aware of the potential negatives of this singular focus, a different type of engineering and design – one that accounts for non-motorized travelers and the environment that surrounds the transportation system – has been and is being demanded. The following section examines the goals and objectives of the Strategic Plan and analyzes ways the objectives and performance measures could be modified to fit better with Complete Streets and Green Streets objectives.

Goal: Safety

Caltrans' goal related to safety is to "**provide the safest transportation system in the nation for users and workers**."[98] However, only one of the three related objectives in Caltrans' 2007-2012 Strategic Plan aims to measure *users* of the transportation system (the other two measure Caltrans worker safety), and it measures *motorized* users:

> Objective 1.1: **By 2008, reduce the fatality rate on the California state highway system to 1.00/100mvmt and continuously reduce annually thereafter toward a goal**

[97] California Department of Transportation. (2006). *Performance Measures for Rural Transportation Systems Guidebook*. Sacramento, CA: California Department of Transportation.
[98] California Department of Transportation. (2007). *Caltrans Strategic Plan 2007-2012*. Retrieved April 10, 2009. from http://www.dot.ca.gov/docs/StrategicPlan2007-2012.pdf. , 44.

of the lowest rate in the nation.

PM 1.1A: **Fatalities per 100 million vehicle miles traveled (mvmt) on the California state highway system**

Measuring fatalities per 100 million VMT obscures significant trends in pedestrian and bicyclist fatalities, as these modes travel only hundreds or in the low thousands of miles each year. Caltrans is attempting to address this lack of measurement through the Strategic Highway Safety Plan (SHSP) as noted above, but their proposed measures use overall amounts rather than rates, thus ignoring the impact of changing amounts of non-motorized travel on the true picture of pedestrian and bicycle safety on Caltrans roadways. It is also important to remember that the term "state highway" refers both to limited access expressways and urban arterials. While the overall number of pedestrian and bicyclist deaths may be low on limited access highways due to low amounts of exposure, urban arterials remain important corridors for pedestrian and bicyclist movement and should be made measured separately to truly monitor and work toward safety.

Goal: Mobility

Caltrans' goal related to mobility is to "**maximize transportation system performance and accessibility**."[99] This goal is subdivided into four objectives, two of which could feasibly affect non-motorized transportation: reducing delay and reducing single occupancy vehicle trips. However, unlike the performance measures from Oregon cited in Chapter II, Caltrans' measure for delay looks at vehicle hours rather than person hours. This focus on vehicles suggests that pedestrian and bicycle delay is not measured.

Objective 2.1: **By 2012, reduce daily vehicle hours or delay by 30,000 hours throughout the transportation system.**

PM 2.1A: **Average daily hours of delay**

[99] California Department of Transportation. (2007), 46.

The second mobility objective aims to reduce single occupancy vehicle trips:

Objective 2.4: **By 2012, reduce single occupancy vehicle commute trips by 5%.**

PM 2.4A: **Percent of single-occupant vehicles as compared to the total commute trips**

This measure is one step Caltrans has taken to promote a more diverse transportation system. However, the objective could be reached through increased carpooling or transit use, and does not directly measure changes in non-motorized facilities or trips. Caltrans mentions non-motorized travel as a strategy for meeting this objective, suggesting an "increase (in) support for non-motorized and promotion/incentives for use of other alternate means of transportation."[100] This strategy is the only direct reference to non-motorized transportation in the entire mobility section. If bicycling and walking are to be encouraged in keeping with the policies and goals described earlier in this chapter, clearly additional objectives and measures dealing specifically with non-motorized transportation are needed.

Goal: Delivery

Caltrans goal for delivery is to "**efficiently deliver quality transportation projects and services**."[101] Because this goal applies to overall project efficiency and not to the delegation of resources, it does not favor one mode or user group over the other and has no direct relation to environmental quality. Therefore, within the proposed new framework presented in Chapter IV, no new objectives or performance measures are proposed for delivery.

Goal: Stewardship

The goal for stewardship is to "**preserve and enhance California's resources and assets**."[102]

[100] California Department of Transportation. (2007), 47, Strategy 2.4.7.
[101] ibid., 48.
[102] California Department of Transportation. (2007), 50.

Most of the objectives for this goal focus on Caltrans' resources, such as pavement, infrastructure, and funding, instead of the natural resources in California. However, objective 4.4 pertains to the natural environment:

> Objective 4.4: **Each year, ensure environmental commitments are documented and implemented on 100% of projects**.
>
> > PM 4.4A: **Percent of projects that have updated environmental commitment records and a Certificate of Environmental Compliance at project closeout**
> >
> > PM 4.4B: **Percentage of projects that have an Environmental Certification, including an updated Environmental Commitments Record, at the ready-to-list (RTL) milestone**

"Environmental commitments" are the actions Caltrans must take to ensure that the *California Environmental Quality Act* (CEQA) is observed during construction. However, CEQA only deals with mitigating possible harm caused by a new project, and does not push Caltrans to improve the existing environment of the transportation corridor, such as mitigating the amount of pollution already present due to travel along the corridor. While this has been the accepted practice for years, the urgency of global climate change and its effects on California's natural environment prompt a reconsideration of this practice to include more mitigating aspects.

One of the proposed performance measures in Chapter IV concerns increasing permeable surface area through landscaping to aid in stormwater retention and reduce the urban heat island effect. Both of these effects should enhance the longevity of the infrastructure, in keeping with goal #6 of the California Transportation Plan, and the quality of the environment for users, in addition to the benefits they provide through water and energy savings. A second proposed measure concerns planting trees along the corridor to increase air pollution interception, provide shade for users and buildings, thereby decreasing energy usage and reducing the urban heat island effect, and provide additional stormwater retention. Enhancing the quality of the corridor through these measures has the complimentary benefit of creating a more pleasant environment for pedestrians

and bicyclists, which may encourage more non-motorized trips and possibly lead to fewer motorized trips.

Goal: Service

The final goal for Caltrans pertains to service, and is to "**promote quality service through an excellent workforce**."[103] This goal is accompanied by several objectives, none of which deal specifically with training for any particular user group. Given the strong history of highway engineering in Caltrans, however, it seems appropriate and may be necessary to encourage training regarding other user groups in order to adequately plan and design Complete Streets. Two of the current objectives are related to this idea, and should provide momentum for complete streets training:

> Objective 5.3: **By 2012, increase by 15% the number of Caltrans employees who agree or strongly agree that employees are encouraged to try new ideas and new ways of doing things to improve Caltrans**.
>
> > PM 5.3A: **Percent of Caltrans employees that agree or strongly agree that employees are encouraged to try new ideas and new ways of doing things to improve Caltrans**.
>
> Objective 5.5: **By 2012, increase by 5% the number of Caltrans employees who agree or strongly agree that the training they have received at Caltrans has adequately prepared them for the work they do**.
>
> > PM 5.5A: **Percent of Caltrans employees who agree or strongly agree that the training they have received at Caltrans has adequately prepared them for the work they do**.

[103] California Department of Transportation. (2007), 53.

Looking Forward

The numerous policy goals and mandates described in this chapter speak to a vision of a completely multi-modal transportation system, which is inherently more sustainable than the current system and its primary focus on motorized single-occupancy vehicles. However, as can be seen from the above analysis of the objectives and measures in current Caltrans' Strategic Plan, work is needed to transform the currently automobile-centric system to one that embraces all users, enhances community quality of life, and takes responsibility for mitigating the adverse local environmental impacts of transportation corridors. The next chapter describes in detail the *Complete, Green Streets Performance Measures Framework for Urban Arterials* proposed to encourage progress toward this more sustainable vision. California has shown national leadership at several key times in its transportation-related history, such as requiring unleaded gasoline in the 1970's and higher fuel standards in the 2000's. The proposed new performance measures represent yet another pivotal opportunity for the State of California to take the lead in transportation policy and practice.

CHAPTER IV: PERFORMANCE MEASURES FRAMEWORK FOR COMPLETE, GREEN URBAN ARTERIALS

This chapter presents a framework of proposed objectives and performance measures that would aid Caltrans in meeting its own internal Directive to improve mobility for non-motorized users and build a Complete Streets network. Recognizing the numerous community and environmental quality benefits that trees and permeable surfaces bring to transportation facilities and the communities they serve, the performance measure framework presented here also incorporates elements of the Green Streets concept. Recognizing as well that improvements to urban arterials will result in the greatest local quality of life benefits, the framework is directed toward them. Specifically, this *Complete, Green Streets Performance Measures Framework for Urban Arterials* it is designed to result in more:

- bicycle and pedestrian facilities and safety features
- people who safely bicycle and walk
- permeable surfaces,
- trees, and
- Caltrans staff trained in the design and maintenance of bicycle and pedestrian facilities.

By combining the proposed measures with Caltrans' existing measures, the agency would take a major step toward creating a meaningful and comprehensive system to measure their progress toward a complete, multimodal and community-serving transportation system.

To make it easy for Caltrans to incorporate these new measures into their current performance measure document, the proposed framework is presented using Caltrans' existing format and structure. Each section begins with the Agency's adopted goals regarding Safety, Mobility, Delivery, Stewardship and Service. Following each goal are proposed objectives, labeled "CGS objectives" (for Complete, Green Streets), and performance measures, labeled using the abbreviation "PM". For reference, Caltrans' existing objectives and performance measures for each goal (already adopted and monitored by Caltrans) are included in the Appendix A of this

document. The numbering of the new (proposed) objectives (i.e., 1.1, 1.2, etc.) and measures will need to be adjusted when they are incorporated with the existing framework.

Table 2 provides a summary of the proposed Complete, Green Streets objectives. The remainder of this chapter provides detail on each proposed objectives and performance measures, including a discussion of how Caltrans can collect the data and set the targets for each measure. In several places, an "X" is used as a placeholder for a year or target where more work is needed before a finite target year (i.e., 2017) or target level (reduce injury rate to 1 per 1 million vehicle miles traveled) could be set. It is recommended that Caltrans apply the same target setting methodology for these new measures that it uses for its existing performance measures, incorporating stakeholder involvement when necessary.

Table 2: Summary of Research Proposal

Proposed Complete, Green Streets Objectives for Caltrans Urban Arterials	
CALTRANS SAFETY GOAL: Provide the safest transportation system in the nation for users and workers.	
CGS Objective 1.1	By 2012, reduce the annual pedestrian and bicycle injury and fatality rates to the following levels, and continuously reduce annually thereafter with the goal of having the lowest rates in the nation. – Pedestrian fatality rate target: X per X walking trips. – Pedestrian injury rate target: X per X walking trips. – Bicyclist fatality rate target: X per X bicycling trips. – Bicyclist injury rate target: X per X bicycling trips.
CGS Objective 1.2	By 2017, double the percentage of people who feel safe using non-motorized modes on urban arterials. By 2022, increase this percentage to XX%.
CGS Objective 1.3	By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase safety for non-motorized users in accordance with Complete Streets principles. By 20XX, all Caltrans urban arterials are designed for safety according to these principles.
CGS Objective 1.4	By 2012, annually reduce the number of pedestrian and bicycle hotspots (high collision concentrations) on urban arterials.
CALTRANS MOBILITY GOAL: Maximize transportation system performance and accessibility.	
CGS Objective 2.1	By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase mobility for non-motorized users in accordance with Complete Streets principles, aiming to link up to a larger community bicycle and pedestrian network where possible. By 20XX, *all* Caltrans urban arterials are designed for non-motorized mobility according to these principles.
CALTRANS DELIVERY GOAL: Effectively deliver quality transportation projects and services.	
	(No new proposed performance measures)
CALTRANS STEWARDSHIP GOAL: Preserve and enhance California's resources and assets.	
CGS Objective 4.1	Annually increase the total mileage of urban arterials designed to minimize negative environmental impacts in accordance with "green streets" principles. By 20XX, *all* urban arterials are designed as "green streets".
CGS Objective 4.2	By 20XX, all Caltrans urban arterials meet a baseline for non-motorized facility quality.
CALTRANS SERVICE GOAL: Promote quality service through an excellent workforce.	
CGS Objective 5.1	Annually increase the number of Caltrans management, design, and maintenance personnel trained regarding Complete Streets principles and Green Streets principles, with the goal of 100% trained.

SAFETY

Goal: Provide the safest transportation system in the nation for users and workers.

CGS Objective 1.1	**By 2012, reduce the annual pedestrian and bicycle injury and fatality rates to the following levels, and continuously reduce annually thereafter with the goal of having the lowest rates in the nation.** – **Pedestrian fatality rate target: X per X walking trips.** – **Pedestrian injury rate target: X per X walking trips.** – **Bicyclist fatality rate target: X per X bicycling trips.** – **Bicyclist injury rate target: X per X bicycling trips.**
PM 1.1a	Rate of pedestrian fatalities per walking trips.
PM 1.1b	Rate of pedestrian injuries per walking trips.
PM 1.1c	Rate of bicyclist fatalities per bicycling trips.
PM 1.1d	Rate of bicyclist injuries per bicycling trips.

Discussion

In existing performance measures, Caltrans tracks the safety of drivers and workers but not of non-motorized users. This omission is incompatible with the Agency's goal to provide a safe system for all users. In many communities, urban arterials serve as central corridors that provide essential mobility and accessibility for pedestrians and cyclists. While traveling on urban arterials; however, pedestrians' and bicyclists' exposure to injury and death is severe compared to automobile drivers'. Because they are not surrounded by the metal buffer of a vehicle, even low-speed crashes can cause severe injuries or death for non-motorized users. Furthermore, research indicates that the likelihood of a pedestrian surviving a crash with a vehicle decreases significantly between the vehicles speeds of 30 and 40 MPH.[104] This is especially significant to this research effort, since vehicles on urban arterials tend to travel at speeds in this range.

Furthermore, there is a growing body of research that quantifies the economic costs to a community of traffic-related injuries and fatalities. According to the National Highway Traffic

[104] Leaf, W.A., & Preusser, D.F. *Literature Review on Vehicle Travel Speeds and Pedestrian Injuries*. Final Report,
DOT HS 809 021, October 1999. Washington, DC: National Highway Traffic Safety Administration

Safety Administration, the total cost in 2000 to the United States of all crashes, including vehicle, pedestrian and bicyclist crashes, was $230.6 billion (in 2000 dollars).[105] Similarly, a review of national studies commissioned by the California Department of Motor Vehicles found that the cost of traffic accidents in California ranges annually from $13 to 49 billion (in 1994 dollars).[106] These costs include losses to property damage and productivity, medical expenses, and other societal costs. As a state agency that is responsible for a major transportation system and community asset, Caltrans should work to reduce these costs to the greatest extent practicable.

Caltrans should adopt a broad, system-wide approach to improving pedestrian and bicyclist safety along urban arterials. Since only some of the transportation facilities in an urban area are state-owned and operated, this safety objective will require Caltrans to coordinate with other jurisdictions and stakeholders who are involved in planning, operating and using the local transportation system. A comprehensive approach that incorporates facility improvements, safety programs and educational campaigns may be required.

Data Collection

Summary: Existing data sources need to be expanded and new data needs to be collected.

For all four of these proposed performance measures, injury and fatality data will come from the existing Statewide Integrated Traffic Records System (SWITRS) data set. The agency will need to adjust its current data entry and reporting technique to isolate pedestrian and bicycle injuries and fatalities. Caltrans may also need to work with local police to ensure that local accident data for all urban arterials is captured.

For walking and bicycle trips, Caltrans should work toward conducting targeted counts of non-motorized trips on urban arterials. To collect this essential data, Caltrans could partner with

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[105] NHTSA(May 2009). *2007 Quick Facts*. DOT HS 811 103. Washington, DC: National Highway Traffic Safety Administration. Retrieved May 5, 2009, from http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/reports/811103.pdf

[106] Peck, Raymond and Healey, Erin. *Accident Costs and benefit Cost Analysis*. 1996. Sacramento, CA: California Department of Motor Vehicles. Retrieved May 5, 2009, from http://www.dmv.ca.gov/about/profile/rd/resnotes/accident.htm

research centers like the University of California Traffic Safety Center and firms like Alta Planning + Design, both of which are currently working on projects that count or model non-motorized trips in California. Until this new data is collected, Caltrans could estimate pedestrian and bicycle trips using existing regional sources, like the Bay Area Transportation Survey (BATS), or from statewide census data.

Some challenges to measuring the rate of pedestrian and bicyclist injury and fatality should be noted. First, there is limited data on the number of pedestrian and bicyclist trips occurring on state urban arterials. While Caltrans works to generate better data on the number of non-motorized trips, statewide modeshare data from the Census can be used as a proxy for walking and biking trips on urban arterials. While this is a functional short-term solution, there are several issues that need to be addressed long-term. First, the Census counts commute trips, which only account for approximately 20% of present-day travel. In addition, it is taken in April, when it is still too cold to walk and bicycle in many parts of the country, thus incorrectly approximating the amount of non-motorized travel at other times of year. It also only counts the mode used for the longest part of the trip, so a trip that is part walking and part bus would be counted as bus if that segment were longer.

Second, this method of measuring the rate of injury and fatality does not specifically account for exposure on Caltrans urban arterials as opposed to other Caltrans facilities. Third, injury and fatality rates can be misleading in cases where there are no deaths or injuries because no one is walking or biking in a certain location. For this reason, overall trips (which are measured in proposed Mobility Objective 2.1) must also be measured and considered in relation to injury and fatality rates. A final challenge with this objective is that pedestrian and bicyclist injuries and fatality records often under-represent the actual number of incidents. Police records do not always accurately record the type of collision and anecdotal evidence suggests that many crashes go unreported. Furthermore, injury and death data from hospitals is rarely gathered and compiled with police report data. For these reasons, the rates calculated for this measure should be used primarily to monitor trends and Caltrans should work with partner agencies to improve the collection of injury and fatality data for pedestrians and bicyclists.

Setting Targets

The proposed target year 2012 is the same target year Caltrans has set for its motorized users and worker safety goal. This year was selected because it is the year of the Agency's next Strategic Plan update. The rate targets (pedestrian injuries per walking trip, etc.) could be set using projections of the decreasing injury and fatality rate over the past several years.

CGS Objective 1.2	**By 2017, double the percentage of Californians who feel safe using non-motorized modes on urban arterials. By 2022, increase this percentage to XX%.**
PM 1.2	Percentage of Californians who feel safe using non-motorized modes on urban arterials.

Discussion

Safety of non-motorized users must be measured in a variety of ways. As mentioned above, measuring safety by counting injuries and fatalities is only one way to look at safety. People's perception of safety plays an important role in their decision to walk or ride a bicycle. Monitoring user attitudes will help to gauge perceived safety amongst all system users, not just those who currently choose to walk or bike. This measure will help the Agency direct projects or programs to areas that might yield to the greatest improvements in perceived safety and use.

Caltrans should begin measuring perceived safety through their annual External Customer Survey, which includes a user survey. Such a survey could be administered to all state residents by mail, as is done by the Oregon DOT. Caltrans could use this opportunity to ask other questions of its users to help measure improvement in other areas. According to the timeline proposed here, Caltrans should administer the first user survey in 2012 in order to set a baseline for the number of system users who feel safe walking and biking on Caltrans urban arterials. As long as Caltrans receives enough responses, the rate can be determined using number of positive responses over the number of survey respondents, which will serve as a statistically significant proxy for population.

Data Collection

Summary: An existing data source must be adapted for this measure.

Caltrans currently conducts an External Customer Survey. This measure would require the addition of one or two new questions to that survey.

Setting Targets

The proposed target years 2017 and 2022 are the years that Caltrans will update its Strategic Plan. By syncing target dates with Strategic Plan updates, Caltrans will have the opportunity to change Strategic Planning priorities to improve upon any areas where targets are not met. This is the approach Caltrans currently uses in setting existing performance measure targets. The 2017 target (double the percentage of people who feel safe…) was set under the assumption that the baseline perceived safety would be relatively low and that Caltrans could use its next Strategic Planning cycle (2012-2017) to make significant improvements on this measure. Once the data is collected and the baseline is determined, this target may need to be reevaluated.

CGS Objective 1.3	By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase safety for non-motorized users in accordance with Complete Streets principles. By 20XX, all Caltrans urban arterials are designed for safety according to these principles.
PM 1.3a	Percent of signalized intersections along 2- or 3-lane arterials with marked crosswalks and one or more of the following: countdown signals, leading pedestrian intervals, bulb-outs, or pedestrian refuge islands.
PM 1.3b	Percent of unsignalized 4-way (multilane) intersections along urban arterials with marked crosswalks and one or more of the following: HAWK signal*, yield to pedestrian signage, user-activated overhead warning lights.
PM 1.3c	Percent of urban arterial intersections with one or more of the following improvements geared toward bicyclists: bike box*, painted bicycle lane through the intersection*, bicycle signal, functioning bicycle loop detectors, bicycle left turn lane.
PM 1.3d	Percent of urban arterials on which the 85th percentile driving speed is no greater than 25 mph.

Discussion

To build Complete Streets, Caltrans must incorporate pedestrian and bicycle safety treatments into all of their urban arterial projects. These performance measures are meant to compliment the previous proposed safety measures (1.1 & 1.2) by measuring physical improvements geared toward pedestrian and bicyclist safety on Caltrans urban arterials. Urban arterials are located in central areas, which typically have a high vehicle through-put. For this reason, Caltrans must target these facilities with special safety features that have been shown to reduce pedestrian and bicyclist collisions and improve perceived safety.

Performance measures 1.3 a, b, and c measure the percent of urban arterial intersections in the Caltrans system where a specified list of treatments (countdown signals, HAWK signals, bike boxes, etc.) are provided. These treatments were selected because there is substantive literature indicating their effectiveness at improving pedestrian or bicyclist safety. Measures 1.3a and b

* It should be noted that the HAWK signals have not yet been approved for use in California, although it is expected to be so in the future. Bike boxes and painted bicycle lanes have been approved for provisional use.

are designed to improve pedestrian safety at two of the most dangerous places along urban arterials: signalized and unsignalized intersections along multilane arterials. Performance measure 1.3c will help Caltrans build Complete Streets by measuring progress toward broadly incorporating bicycle safety into the design of urban arterials, particularly at intersections.

It is important to note that these measures are not meant to prescribe design treatments for urban arterial intersections or to result in all treatments being used at all locations. Instead, Performance Measures 1.3 a, b, and c provide designers with a list of approved treatments that have a demonstrated effect on motorist, pedestrian or bicycle behavior and safety, with the goal of a system-wide increase in the application of these treatments. The list of safety treatments in Performance Measures 1.3a, b, and c will encourage Caltrans designers to use their professional judgment to design context-sensitive solutions that suit each intersection. As with all traffic facilities, careful design will be essential. Especially for treatments that have not been widely applied in California, such as bike boxes and bicycle left turn lanes, close consultation with design guidelines (*like the AASHTO Greenbook or the AASHTO Design Manual*[107]) and/or with pedestrian and bicycle design professionals may be necessary.

While Performance Measures 1.3 a, b and c focus specifically on intersections, urban arterials must also be designed to promote safety of users traveling along a road section. Performance Measure 1.3d gauges the "percent of urban arterials on which the 85th percentile driving speed is no greater than 25 mph" and is intended to address design speed. While the mission of Caltrans is to improve mobility in California, historically in the transportation field, improving mobility has meant increasing driver speeds. Increasing vehicle speeds, however, can be highly detrimental to driver, pedestrian and bicyclist safety. In order to build Complete Streets, Caltrans must apply a balanced approach that provides multimodal mobility without sacrificing the safety of any users.

[107] See also Zegeer, C. V., C. Seiderman, P. Lagerwey, M. Cynecki, M. Ronkin, and R. Schnieder. 2002a. *Pedestrian facilities users guide—Providing safety and mobility*. Report No. FHWA-RD-102-01. Washington, DC: Federal Highway Administration.

In the State of California, speed limits are set using requirements in the California Vehicle Code, which states that the speed on multilane State highways (which includes State urban arterials) will be 55 MPH unless a traffic and engineering study has shown that speed is not reasonable or safe in that location. On the other hand, on a non-State highway in a business or residential district, the Vehicle Code sets the speed limit at 25 MPH. Although these speeds can be adjusted by the DOT or by the local government through a series of studies and petitions, it does not seem reasonable that, in urban areas, State and local arterials should be treated so differently.

Furthermore, localities can petition to have their speed changed if they demonstrate that 85% of drivers are driving a certain speed. In other words, the 85th percentile rule adjusts the law (speed limit) to fit the behavior (actual speed). According to the Vehicle Code, "a reasonable speed limit is one that conforms to the actual behavior of the majority of motorists, and by measuring motorists' speeds, one will be able to select a speed limit that is both reasonable and effective." While this system may be appropriate on freeways and major highways, it is not suited to urban environments where roads are shared by a variety of users. Research has shown that posted speed limit signs appear to have a limited effect on reducing driver speeds when not accompanied by enforcement and roadway design.[108] While enforcement can be effective, it is a reactive approach that is limited by financial resources. The most proactive and long-term approach is to design arterials for the safest and most appropriate behavior (actual speed) for each location.

Especially in urban areas, where arterials may serve as main streets or host some level of community activity, speed and its implications for user safety must be incorporated at the outset of transportation project design. There is a range of design treatments that can help accomplish desired vehicle speeds and increase user safety while maintaining system throughput. Since the most effective and feasible design treatment for achieving target speeds will vary greatly between projects, Performance Measure 1.3d maintains a high level of professional discretion for Caltrans designers by measuring an output (driver speed) rather than any particular physical feature of the roadway. In some conditions, speed-calming measures such as center islands or

[108] Mannering, F. (2008). *Speed limits and safety: A statistical analysis of driver perceptions*. Paper presented at the Transportation Research Record.

raised intersection crosswalks may be appropriate. Lane narrowing may also be a desirable approach, especially on urban arterials and in places with limited right-of-way. Narrowing lane widths has been associated with slower driving speeds[109] and accident rates that were either reduced or unchanged.[110] According to the AASHTO *Green Book*, urban arterials lane widths may vary from 10 to 12 feet. The *Green Book* states that 12-foot lanes may be most appropriate on higher speed, free flowing, principal arterials. However, on signalized arterials operating at less than 45 MPH (all urban arterials), "narrower lane widths are normally quite adequate and have some advantages." Furthermore, it has been demonstrated that vehicle capacity is minimally or not at all affected by a reduction of lane widths from 12 to 10 feet.[111]

Data Collection

Summary: A new process for collecting and analyzing data is required for these measures.

For performance measures 1.3 a, b, and c, data for measuring new projects/expenditures should be collected from the final design documents for individual projects. A new form may be needed to collect this data. For measuring system-wide facilities, data must be compiled from each of the Caltrans regional districts. A new database or GIS file could be created to ease in the evaluation of this measure.

For performance measure 1.3d, Caltrans will need to collect new speed data on urban arterials. Caltrans could use automated speed monitors or could partner with state or local law enforcement.

Setting Targets

Since Caltrans' Complete Streets Deputy Directive (DD-64-R1) was issued in October of 2008, it is reasonable that the Agency could be designing all new projects as Complete Streets by 2012

[109] Fitzpatrick, K., Carlson, P., Brewer, M., & Wooldridge, M. (2000). Design Factors That Affect Driver Speed on Suburban Streets. *Transportation Research Record, 1751*, 18-25.

[110] Harwood, DW, (2000) NCHRP Report 330: Effective Utilization of Street Width on Urban Arterials, *TRB, National Research Council*, Washington, DC.

[111] John Zegeer, P.E., (past Chair, TRB Jighway Capacity and Quality of Service Committee) in a memo to Sprinkle Consulting Engineers, March 22, 2007.

(the year of the next Strategic Plan update). The three-year interim gives the Agency time to adjust their design procedures and train staff as needed. The future target year (20XX) should be selected to give the agency enough time to retrofit existing urban arterials to be designed according to Complete Streets principles. Caltrans may choose to conduct a facility safety audit, to determine the timeline and cost of meeting this target. The target for each performance measure, which works toward all facilities designed for safety according to Complete Streets principles, will be 100%.

CGS Objective 1.4	By 2012, annually reduce the number of pedestrian and bicycle hotspots (high concentration of collisions) on urban arterials.
PM 1.4a	Overall number of pedestrian collision hotspots on urban arterials.
PM 1.4b	Overall number of bicycle collision hotspots on urban arterials.

Discussion

Even as Caltrans succeeds in reducing the overall system rate of pedestrian and bicyclist injury and fatality, the Agency must work to address its most unsafe locations. Caltrans already has a process for mapping and responding to vehicle collision hot spots, functionally defined in the Agency as any cluster of collisions. This performance measure simply extends that process to bicycle and pedestrian collision clusters as well. Since this performance measure applies only to urban arterials, hot spots should be analyzed for collisions occurring on similar road types, as is currently done for automobiles. Also, since pedestrian, bicyclist, and driver safety each depend on a different set of roadway characteristics, it is essential that each mode is analyzed individually.

Data Collection

Summary: Existing data sources will have to be altered for these measures.

For both of these measures, injuries and fatalities could be mapped using data from the Statewide Integrated Traffic Records System (SWITRS), though the Agency will need to change their data entry and reporting technique to isolate pedestrian and bicycle injuries and fatalities.

Setting Targets

If Caltrans is continually working to address areas of concentrated injury and fatality, the agency's goal should ultimately be to have zero hotspots. This performance measure must be addressed in coordination with an effort to reduce the overall rate of pedestrian and bicycle injury (as captured in proposed performance measure 1.1).

Goal: Maximize transportation system performance and accessibility.

CGS Objective 2.1	**By 2012, all Caltrans urban arterial projects (new expenditures) are designed to increase mobility for non-motorized users in accordance with Complete Streets principles, aiming to link up to a larger community bicycle and pedestrian network where possible. By 20XX, *all* Caltrans urban arterials are designed for non-motorized mobility according to these principles.**
PM 2.1a	On urban arterials, ratio of sidewalk mileage to roadway mileage, bi-directionally.
PM 2.1b	On urban arterials, ratio of Class II bicycle facility mileage to roadway mileage, bi-directionally.
PM 2.1c	On urban arterials, percentage of intersections that are ADA compliant.
PM 2.1d	Percentage of urban arterial projects designed as Complete Streets.
PM 2.1e	Number of pedestrian trips on urban arterials.
PM 2.1f	Number of bicycle trips on urban arterials.

Discussion

To accomplish its Complete Streets directive, Caltrans must begin measuring the mobility provided to system *users*, not to automobiles. Mobility is the ability and efficiency, usually measured in time, with which one can move between places. Measuring mobility for pedestrians and bicyclists is very different than doing so for automobiles. For bicyclists and pedestrians, the first measure of mobility is whether a reasonable travelway exists for them to walk or bike on. For this reason, the Complete Streets mobility performance measures begin with 2.1a and b, which measure the system-wide presence of sidewalk and Class II bicycle facilities, respectively, in comparison to roadway miles. It is important to note that broader system connectivity will be important in providing pedestrian and bicyclist mobility. To accomplish this, Caltrans should work with local jurisdictions and consider how bicycle and pedestrian facilities on urban arterials connect to surrounding streets. Furthermore, Caltrans should incorporate local bicycle and pedestrian plans into the design of urban arterial facilities.

In addition to measuring the presence of a facility for non-motorized users, the Agency must measure the accessibility of that facility to people with disabilities. The Americans with Disabilities Act (ADA) requires that governments provide accessibility for people with disabilities to all public services and facilities. With regards to new projects in the public realm, ADA has led to a near-universal application of ramps and curb warning systems at intersections, wheelchair-accessible push buttons at crossing signals, and many other features. Since ADA was passed in 1990, however, most jurisdictions have not been able to retrofit all of their pre-existing facilities to ADA compliance, due to financial limitations. Central to the Complete Streets concept, however, is the idea that the streets are public spaces that can be used by everyone. California's progress toward ADA compliance on all facilities is an important measure of their progress toward Complete Streets. For this reason, performance measure 2.1c measures the percentage of intersections that are ADA compliant. Intersections, rather than entire sections of roadway, are measured for reasons of feasibility – but Caltrans should work toward accessibility on all of its facilities.

Performance measure 2.1d directly tracks the Agency's progress toward designing transportation projects, specifically urban arterials, as Complete Streets. One might find this measure duplicative with other measures proposed here, but this is the measure that considers all modes and travelers simultaneously. If Caltrans is making improvements on each of the other new measures proposed here, this measure will also steadily improve. To determine if the facility qualifies as a Complete Street, Caltrans should adopt a scorecard that can be used in the final design phase of project development.

While the existence and design of a facility is important, people's decision to walk or bike depends on a wide range of factors. Performance measures 2.1e & f count the actual number of trips made by pedestrians and bicyclists on urban arterials. This measure incorporates the outcomes of the facility-oriented work addressed by the previous proposed measures and thus, allows the agency to measure multimodal mobility in a comprehensive way.

Data Collection

Summary: New data methods will need to be generated for these measures.

For measures 2.1 a, b, and c, Caltrans will need to complied facilities data from each of the regional District offices. A unified database or GIS file might ease in reporting for this measure.

For measure 2.1d, Caltrans will need to develop or adopt a scorecard/checklist for determining whether a facility qualifies as a Complete Street.

For measures 2.1 e and f, Caltrans should work toward conducting targeted counts of non-motorized trips on urban arterials. This data is also required for proposed CGS Objective 1.1.

Setting Targets

2.1a: Along urban arterials, the target ratio of sidewalk mileage to roadway mileage should be 1 (all urban arterials have sidewalks on both sides).

2.1b: Recognizing that there are some streets where bicycle facilities are not possible or necessary due to space constraints, lower traffic volumes, lower vehicle speeds or other factors, the target for the ratio of Class II bicycle facility mileage to roadway mileage should steadily increase from year to year. A finite target may not be necessary.

2.1c: Since federal law requires that all public facilities are ADA accessible, the target for percent of intersections that are ADA compliant should be 100%.

2.1d: In 2012 and in 20XX, the percent of urban arterial projects designed as Complete Streets should be 100%. The future target year (20XX) should be determined using similar methods discussed in previous sections, through a facilities audit and budget/timeline projection.

2.1e, f: The target for the number of pedestrian and bicycle trips on urban arterials should be a steadily increasing number each year. If the Agency wants to set a finite target, it can measure trips for several years, determine an annual rate of change, and propose a steady increase to that rate of change.

DELIVERY

Goal: Effectively deliver quality transportation projects and services.

(No proposed measures)

STEWARDSHIP

Goal: Preserve and enhance California's resources and assets.

CGS Objective 4.1	**Annually increase the total mileage of urban arterials designed to minimize negative environmental impacts in accordance with Green Streets principles. By 20XX, *all* urban arterials are designed as Green Streets.**
PM 4.1a	Ratio of pervious to impervious surfaces on Caltrans urban arterials, including medians, buffer strips, and planter holes.
PM 4.1b	Percent of urban arterial lane mileage with tree canopy coverage.

Discussion

The view of Stewardship within existing Caltrans performance measures is very narrow – it primarily measures pavement and bridge conditions, equipment availability and the obligation of some types of funding. Caltrans has a responsibility to Californians to broaden its approach to Stewardship and recognize the important role that the Agency plays in the protection and preservation of the state's natural resources. Maintaining facilities is important, but stewardship should be viewed more broadly as the agency's responsibility to the users and communities where Caltrans facilitates are located. Proposed performance measures 4.1a and b will allow the Agency to work towards its Stewardship Goal to "Preserve and Enhance California's Resources and Assets" more holistically.

To become a successful steward of the State's resources, Caltrans should incorporate Green Streets principles into the design of urban arterials. Green streets are designed with the maximum canopy coverage and permeable surfaces practicable. These principles are incorporated into this proposed performance measure framework because of the role that greenery can play at improving the traveler experience on urban arterials. Trees in particular can improve the thermal equivalent index by creating shade and can attract people to travel through a business district. The shade can also help reduce the urban heat island effect, which is the increase in ambient air temperature created by the reflective properties of pavement. Beyond traveler experience, landscaping and trees can filter and reduce storm water runoff, sequester

carbon, and mitigate other air pollution caused by vehicle traffic. Trees bring about energy savings through building shading, and can promote social equity by improving air quality and providing an amenity to neighborhoods with high amounts of auto traffic. For all these reasons, Caltrans has a responsibility related to its Stewardship Goal to design its urban arterials as green streets.

Proposed performance measure 4.1a measures the ratio of pervious to impervious surfaces on Caltrans urban arterials. This ratio will improve with each new planted median strip, buffer and tree that Caltrans incorporates into its projects. Performance measure 4.1b measures the urban arterial land mileage with tree canopy coverage. Canopy coverage is an important part of the pedestrian experience and is also a measure of the potential environmental benefits a tree-lined street provides.

Data Collection

Summary: New data sets will have to be created for these measures.

For performance measure 4.1a, an annual survey of a random sample set of urban arterial segments will be required. It is possible that this could be done in tandem with the annual pavement survey.

For performance measure 4.1b, Caltrans will first need to set a baseline, which could be done by estimating canopy coverage from aerial images. This baseline should be re-evaluated every five years. In the interim years, the Agency should estimate canopy coverage from the final design documents of new projects. Canopy measurements should estimate the expected size at maturity, and trees that are unhealthy or dying should not be included (see Appendix B for a demonstration of estimating pervious surfaces and canopy coverage).

Setting Targets

No additional target setting is required.

CGS Objective 4.2	By 20XX, all Caltrans urban arterials meet a baseline for non-motorized facility quality.
PM 4.2a	Percent of urban arterial sidewalk mileage in fair or better condition.
PM 4.2b	Percent of urban arterial bicycle lane mileage in fair or better condition.

Discussion

As part of their existing Performance Measure framework, Caltrans monitors distressed pavement through an annual pavement survey. The Agency also monitors the maintenance of road striping, guardrails and the overall roadway. There is no measure, however, specifically for the upkeep of bicycle and pedestrian facilities. To meet the mandate of the Complete Streets Deputy Directive, Caltrans must broaden its Stewardship objectives to include maintenance of all facilities, including sidewalks and bicycle lanes.

For pedestrians, cracks or gaps in the sidewalk can be a tripping hazard and can create a barrier for people with disabilities and other users. Poor sidewalk conditions also create an unappealing environment for walking and can discourage pedestrians from using a facility. For bicyclists, the condition of the pavement and maintenance of the facility can play an important role in a person's decision whether to ride. Failing pavement conditions in a bicycle lane can create uncomfortable and unsafe conditions. Litter and debris from the roadway often collect in bicycle lanes, further reducing the appeal and performance of a facility. Also, when pavement markings for bicycle lanes are not maintained, cyclists' safety may be threatened when drivers become unaware of the presence of the facility. As with all transportation facilities, maintenance and upkeep are essential to the function of bicycle and pedestrian travelways.

Data Collection

Summary: Existing data collection process will have to be adapted for this measure.

For both of these measures, data should be collected through an annual survey done in coordination with the existing pavement condition survey.

Setting Targets

Caltrans may need to develop a uniform method for grading sidewalk and bicycle facility conditions. The Agency should use a similar method to that presently used in the existing pavement survey.

SERVICE

Goal: Promote quality service through an excellent workforce.

CGS Objective 5.1	**Annually increase the number of Caltrans management, design, and maintenance personnel trained regarding Complete Streets principles and Green Streets principles, with the goal of 100% trained.**
PM 5.1a	Number of personnel trained in Complete Streets principles.
PM 5.1b	Number of personnel trained in Green Streets principles.

Discussion

Since the design and maintenance of bicycle and pedestrian facilities has not always been central to the work of Caltrans, many Agency employees will need special training in order to implement projects that work toward Complete Streets. As stated, the design and maintenance of a bicycle and pedestrian facility will play an important role in a users' choice of mode. Especially since the selection and design of the most appropriate bicycle or pedestrian treatment will vary from site to site, designers must have expansive and current knowledge of best practices in facility design and function. The same is true for maintenance of facilities and collection of data related to bicycle and pedestrian travel. For this reason, it is essential that Caltrans work to expand the capacity and knowledge of the design, maintenance and management staff on a variety of issues that relate to facilities for non-motorized users.

Some of the required trainings may be developed and offered by Caltrans. For example, Caltrans may want to establish a new training for design staff on how to determine whether a certain design qualifies as a Complete Street. Other training opportunities may be offered by outside providers like the Institute of Transportation Engineers or by a bicycle and pedestrian design firm.

Caltrans staff will also need to be trained on designing, building and maintaining Green Streets. Specific elements related to the placement, species and spacing of trees, the size of buffers and tree wells, and the design of medians can determine extent of the safety and quality of life

benefits these investments will bring to surrounding communities. Informed design and maintenance will ensure that this public investment in infrastructure and landscaping will yield meaningful and long-term results. The Green Streets movement is still evolving and may not offer a variety of specific training programs, but there are a range of landscape programs that would allow Agency staff to work towards meeting the new Objectives that relate to tree canopy coverage and permeability.

Data Collection

Summary: New data will need to be generated for this measure.

For both of these measures, Caltrans will need to develop an ongoing log of personnel trainings.

Setting Targets

No additional target setting required.

CHAPTER V: CONCLUSIONS AND NEXT STEPS

The *Complete, Green Streets Performance Measures Framework for Urban Arterials* presented in this report is meant to provide Caltrans with the supplementary measures needed to monitor pedestrian and bicyclist safety and the environmental health of its urban arterials. It was created in response to recognition by the Agency of its historic lack of attention to these aspects of the transportation system, and an increasing need to address them to combat several major current issues. Urban arterials were chosen for the focus because they carry high amounts of local traffic, particularly pedestrians and bicyclists, due to their density of attractions such as businesses, restaurants, and stores. As recommended in the 2004 NCHRP report on the use of performance measures by DOTs, these proposed measures are tailored to fit within the present context of the organization and include a balance of both project- and organization-level measures, as well as both process and outcome measures. The proposed *Complete, Green Streets Performance Measures Framework* aims to position Caltrans at the forefront of state transportation agencies with regard to measuring and accommodating non-motorized travel and the surrounding environment.

Adopting and Implementing the New Performance Measurement Framework

Although essential to Caltrans meeting its internal Complete Streets Directive and other goals, adopting and implementing these new performance measures will present Caltrans with a series of challenges. First, as has already been mentioned, collecting the data required by these performance measures will be costly and time-consuming; especially initially as baselines are set and new procedures are established. Where possible, the proposed measures use existing data; seven of the proposed measures use data from existing sources that can be examined from a different angle. However, the other 16 proposed measures require new data sources to provide the information necessary for analysis. Although this will create a recognizable administrative burden, it is widely acknowledged that collecting new data is a necessary step in measuring new outcomes. Expanding and adapting the data sets that Caltrans uses will be central to the Agency's practice of accountability and responsible transportation planning.

In addition to collecting data and setting baselines, Caltrans will need to set target results and years for many of the proposed performance measures. In some cases, target results have been proposed according to the plans and policies inspiring the objectives; in others, they were left undefined, as Caltrans needs to first set baselines and work from there to determine the appropriate targets. Caltrans may choose to follow their current practice of setting target years in five-year increments, corresponding to their Strategic Plan updates. As stated throughout the body of research on performance measurement, targets should be realistic enough to be achievable, but aggressive enough to inspire meaningful change. Caltrans may find that identifying targets is an undertaking best accomplished by a task force of staff from various internal departments and representative outside stakeholders.

A broad issue that Caltrans faces in implementing these measures is that building context sensitive, community-serving transportation facilities is complicated, especially compared to building roads that are designed to serve one central function. Getting to Complete, Green Streets will require a multidisciplinary approach, where engineers, landscape architects, planners, community members and other stakeholders contribute at every phase of project development, from design to implementation to post-occupancy evaluation. Building Complete, Green Streets will also require the Agency to balance a wide range of desired outcomes. A maxim that has been applied to past transportation projects to ensure that compromise is applied to the greatest extent possible is "everyone gets something, no one gets everything." In other words, every person affected by a transportation project, including bicyclists, pedestrians, shoppers, merchants, neighbors, and drivers, gains something but also may have to share space, slow down or adjust their expectations slightly to accommodate other users. While it is certain that collaborative, multimodal planning requires a different approach than traditional highway design, Caltrans already applies this approach to many of their projects and has the capacity to expand this practice to all of their work.

The result of implementing the proposed *Complete, Green Streets Performance Measures Framework for Urban Arterials* should be a Caltrans roadway system that better accommodates pedestrians and bicyclists and contributes to environmental sustainability and the community through stormwater retention, air pollution interception, beautification, and shade production. If

adopted, these measures will provide State taxpayers a way of holding the government accountable in their role as stewards of valued community spaces, and allow Caltrans to demonstrate significant leadership within the transportation field.

APPENDIX A: EXISTING CALTRANS GOALS, OBJECTIVES AND PERFORMANCE MEASURES

Existing Caltrans Goals, Objectives and Performance Measures

SAFETY GOAL: Provide the safest transportation system in the nation for users and workers.

Objective 1.1 By 2008, reduce the fatality rate on the California state highway system (SHS) to 1.00 per 100 million vehicle miles traveled and continuously reduce annually thereafter toward a goal of the lowest rate in the nation.

PM 1.1 Traveler Safety – Fatalities per 100 MVMT on the California state highway system.

Objective 1.2 Each year, ensure zero work-related fatalities.

PM 1.2 Worker Safety – Number of work-related fatalities.

Objective 1.3 By 2012, reduce the work-related injury and illness incident rate for transportation workers by 25%.

PM 1.3 Worker Incident Rate – Work-related injuries and illnesses in previous 12 months per 200,000 employee hours.

MOBILITY GOAL: Maximize transportation system performance and accessibility.

Objective 2.1 By 2012, reduce daily vehicle hours of delay by 30,000 hours throughout the transportation system.

PM 2.1a Statewide daily vehicle hours of delay (DVHD).

PM 2.1b Percent of good (operating) detectors (CMIA corridors).

PM 2.1c Percent of good (operating) detectors (overall).

PM 2.1d Percent of detection coverage (CMIA corridors).

PM 2.1e Percent of detection coverage (overall).

Objective 2.2 By 2012, increase reliability by 10% throughout the transportation system.

PM 2.2a Percent variation from predicted travel time (with reliable real-time detection).

PM 2.2b Percent of major incidents cleared in less than 90 minutes.

Objective 2.3 By 2012, increase intercity rail ridership on the State-supported routes by 28%.

PM 2.3a Intercity rail ridership by route (Pacific Surfliner, San Joaquin, and Capital Corridor), and total ridership for the three routes.

PM 2.3b Farebox ratio for intercity rail (Pacific Surfliner, San Joaquin, and Capital Corridor).

Objective 2.4 By 2012, reduce single occupancy commute trips by 5%.

PM 2.4a Single occupancy vehicle as a percentage of total trips.

PM 2.4b Percent of available funds used for Mass Transportation projects that pass through Caltrans to local recipients.

DELIVERY GOAL: Effectively deliver quality transportation projects and services.

Objective 3.1 By 2012, impact the overall cost to deliver capital projects by:

a. Reducing the support to capital ratio to 32% or lower;
b. Reducing the overhead cost to 13%.

PM 3.1a Capital outlay support cost to capital cost ratio (as Construction Contract Acceptance [CCA] milestone).

PM 3.1b Percent overhead cost.

Objective 3.2 Each fiscal year, meet 100% of project delivery milestones.

PM 3.2a Percent delivery of Project Approval/Environmental Document (PA/ED) milestones.

PM 3.2b Percent delivery of planned Right of Way (R/W) Certification milestones.

PM 3.2c Percent delivery of planned Ready to List (RTL) milestones.

PM 3.2d Percent delivery of planned Construction Contract Acceptance (CCA) milestones.

PM 3.2e Number and percent of cooperative agreements executed within 60 days of signing authorizing document.

Objective 3.3 By 2012, ensure 100% of projects meet their approved purpose and need at project completion.

PM 3.3 Percent of projects that meet their approved purpose and need at project completion.

Objective 3.4 Each year, ensure that the total construction costs of projects do not exceed 100% of their total original allotment.

PM 3.4 Total construction cost of projects at Proposed Final Estimate (PFE) as a percentage of total original contract allotment.

Objective 3.5 Each year, keep the total of all low bids within +/- 5% of the total of all engineers' estimates.

PM 3.5a Percent difference between total low bids and total engineer's estimates.

PM 3.5b Percent of projects with low bid within +/- 10% of engineer's estimate; and Percent of projects with low bid greater than 110% of engineer's estimate.

STEWARDSHIP GOAL: Preserve and Enhance California's resources and assets.

Objective 4.1 By 2012, ensure that distressed pavement does not exceed 30% of the system's lane miles.

PM 4.1a Pavement Condition – Percent of distressed lane miles.

Objective 4.2 Each year, ensure that 100% of Caltrans' financial resources are available when and where needed.

PM 4.2a Percent of federal subvention formula funds obligated for local projects (on/off State highway system).

PM 4.2b Timely use of funds – Percent of unexpended obligational authority (OA) balance that is deemed inactive and subject to quarterly review.

PM 4.2c Percent of invoices issued to individuals or entities that own the Department money prepared within 30 calendar days of receipt of documentation.

PM 4.2d Percent of total payments made to vendors and other government agencies within the time limits imposed by the Prompt Payment Act or as specified in the contract.

PM 4.2e Percent of employees payments processed within 10 working days of receipt of Travel Expense Claim (TEC) by Accounting.

Objective 4.3 By 2012, increase maintenance level of service (LOS) scores to:

- 80 in Litter and Debris
- 95 in Striping
- 95 in Guardrail
- 87 for overall roadway level of service.

PM 4.3a Maintenance LOS in Litter and Debris.

PM 4.3b Maintenance LOS in Striping.

PM 4.3c Maintenance LOS in Guardrail.

PM 4.3d Maintenance LOS in overall roadway.

Objective 4.4 Each year, ensure environmental commitments are documented and implemented on 100% of projects.

PM 4.4a Percentage of projects that have an updated Environmental Commitments Records and a Certificate of Environmental Compliance at project close.

Objective 4.5 Each year, dispose of 100% of the parcels identified as excess in the annual Real Property Retention Review.

PM 4.5 Percent of parcels identified in the Excess Land Disposal Plan and disposed of.

Objective 4.6 Identify all critical infrastructure deficiencies for facilities by 2010 and remediate 25% of the deficiencies by 2012.

PM 4.6 Percent of facilities with critical infrastructure deficiencies remediated.

Objective 4.7	Manage Caltrans' assets (human resource, information, facilities, and equipment) efficiently and effectively to ensure that 100% of its authorized resources are protected and available when and where needed.
PM 4.7a	Percentage of equipment that is available to the user (fleet uptime).
PM 4.7b	Percent approval rating of the Legal Division from an annual performance survey of senior Department managers.
PM 4.7c	Percent of the tort, eminent domain and contract cases in which Legal Division obtains favorable results.
PM 4.7d	Percent of external audits identified in the annual service plan that are completed.
PM 4.7e	Percent of mandated audits that are completed.
Objective 4.8	By 2012, reduce the number of distressed bridges to 5% of all bridges.
PM 4.8a	Bridge Condition – Number and percent of distressed bridges.
PM 4.8b	Bridge Condition – Network bridge health index (BHI) number.
PM 4.8c	Bridge Condition – Percent of State-owned bridges classified as structurally deficient or functionally obsolete (SD/FO).

SERVICE GOAL: Promote quality service through an excellent workforce.

Objective 5.1	Each year, ensure that the attrition rate at Caltrans does not exceed 4%.
PM 5.1	Employee Attrition Rate – Percent.
Objective 5.2	Each year, ensure 100% compliance with response times and scheduled milestones for Local Assistance, oversight, and permits, as negotiated with out local partners and other submitting entities.
PM 5.2a	Percent of "Request for Authorization to Proceed" packages submitted by local agencies that are reviewed and processed by Caltrans and are ready for submittal to FHWA within 30 days of receiving the complete and accurate request.
PM 5.2b	Percent of encroachment permits approved within the statutory 60-day limit.
Objective 5.3	By 2012, increase by 15% the percentage of Caltrans employees who agree or strongly agree that employees are encouraged to try new ideas and new ways of doing things to improve Caltrans.
PM 5.3	Percent of Caltrans employees who agree or strongly agree that employees are encouraged to try new ideas and new ways of doing things to improve Caltrans.
Objective 5.4	By 2012, increase by 15% the percentage of external stakeholders who are satisfied with Caltrans services.
PM 5.4a	Percent of survey respondents who said Caltrans was doing a good or excellent job.
PM 5.4b	Percent of survey respondents who said Caltrans was doing a good or excellent job in fulfilling its mission of improving mobility across California.

PM 5.4c	Percent of survey respondents who said: "Over the last two years, Caltrans' performance has improved, gotten worse, stayed about the same, or don't know."
Objective 5.5	By 2012, increase by 5% the percentage of Caltrans employees who agree or strongly agree that the training they have received at Caltrans has adequately prepared them for the work they do.
PM 5.5	Percent of Caltrans employees who agree or strongly agree that the training they have received at Caltrans has adequately prepared them for the work they do.
Objective 5.6	Increase the percentage of Caltrans employees who rate Caltrans management as good or very good at being open and honest in communications with employees, by (from baseline) 15% in 2008, 30% in 2010, and 50% in 2012.
PM 5.6	Percent of Caltrans employees who rate Caltrans management as good or very good at being open and honest in communications with employees.
Objective 5.7	By 2012, increase by 15% the percentage of Caltrans employees who agree of strongly agree that they are satisfied with the availability of the tools necessary to do their job.
PM 5.7	Percent of Caltrans employees who agree of strongly agree that they are satisfied with the availability of the tools necessary to do their job.
Objective 5.8	By 2012, increase by 20% the percentage of first-choice candidates that accept the Department's entry-level job offers.
PM 5.8	Percent of first-choice candidates that accept the Department's entry-level job offers.

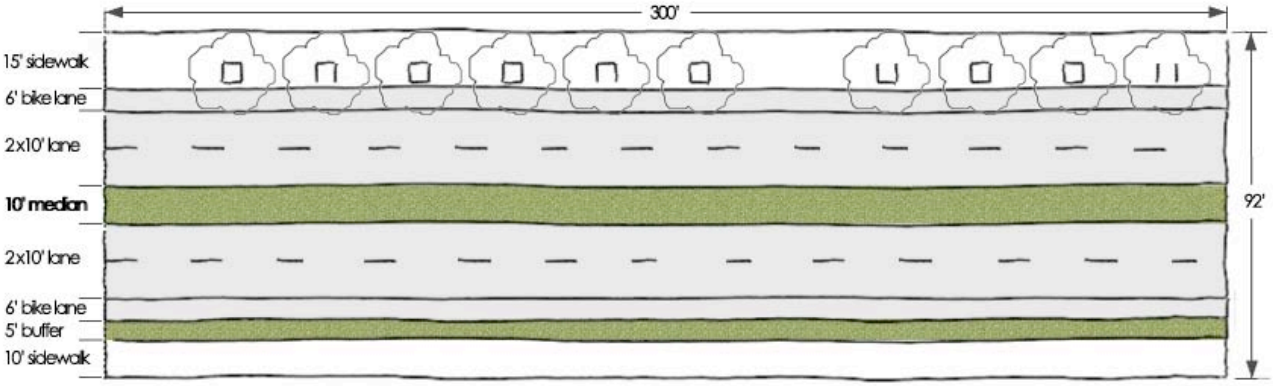
APPENDIX B: ESTIMATING CANOPY COVERAGE

ESTIMATING THE RATIO OF PERVIOUS TO IMPERVIOUS SURFACES FOR PROPOSED PM 4.1A:
Note: Caltrans should generate a random selection of urban arterials to sample for this measure and determine a uniform segment length that will be feasible and appropriate

Pervious Surface Area Calculation: (# of tree wells * area of tree wells) + (area of planted median) + (area of planted buffer) + (area of other pervious surface)

Impervious Surface Area Calculation: (Total area of urban arterial segment) − (Pervious surface area, as calculated above)

Example: (Uses a 300' segment length)



Pervious Surface Area Calculation: (10 * 25 sq. ft.) + (3,000 sq. ft.) + (1,500 sq. ft.)
= 4,750 sq. ft. pervious
Impervious Surface Area Calculation: (300 ft. * 92 ft.) − (4,750 sq. ft.)
= 22,850 sq. ft. impervious
Ratio Pervious to Impervious: (4,750/22,850) = **.2079**

ESTIMATING THE PERCENT OF URBAN ARTERIAL LANE MILEAGE WITH TREE CANOPY COVERAGE FOR PROPOSED PM 4.1B:

Step 1: Set a baseline for canopy coverage on all (or a representative sample) Caltrans urban arterials. Update baseline periodically (possibly every five years).
Total urban arterial lane mileage = (length of urban arterials) * (number of lanes)
Percent Canopy Coverage (baseline) =
(Total length [diameter] of existing canopy, including median trees) ÷ (Total urban arterial lane mileage)

Step 2: Annually update baseline using final design drawings for new projects.
Percent Canopy Coverage (annual update) =
(Total length of existing canopy from baseline) + (Total length [diameter] of canopy coverage from new projects) ÷ (Total urban arterial lane mileage, including new projects)

APPENDIX C: REFERENCES

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