Final Report

Incorporating the Smart Mobility Framework into a Corridor System Management Plan

Caltrans District 4, Contra Costa County

Final

February 2015

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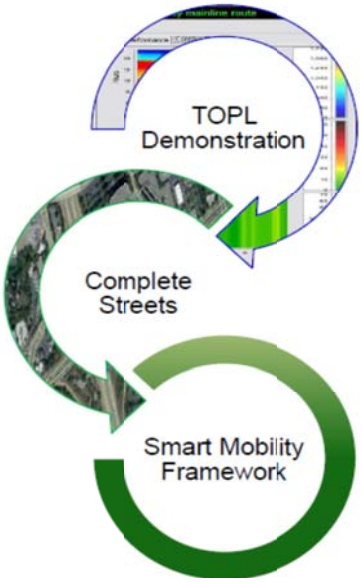
Section 1
Executive Summary

EXECUTIVE SUMMARY

The Contra Costa County Interstate 680 (I-680) Corridor System Management Plan (CSMP) is the first second generation CSMP in the state. Previous CSMP efforts presented an analysis of existing and future traffic conditions and proposed traffic management strategies and transportation improvements to maintain and enhance mobility for specific segments of the most congested corridors in District 4. As a second generation CSMP, this effort also incorporates three new planning elements:

- Tools for Operational Planning (TOPL) – As a new tool being developed by the University of California at Berkeley's Partners for Advanced Transportation Technology (PATH) program, the CSMP was the first large-scale demonstration of the TOPL tool.
- Complete Streets – In response to the state's Complete Streets Act of 2008 and Caltrans' *Deputy Directive-64-R1,* evaluation and provisions for safe mobility of all users, including transit riders, bicyclists, and pedestrians, were included.
- Smart Mobility Framework (SMF) – Elements of the SMF, such as the principles, place types, and performance measures, were incorporated throughout the planning process.



Source: System Metrics Group, 2013.

Figure 1. I 680 CSMP Components

The Contra Costa I-680 CSMP Final Report[1] presents and summarizes the effort.

This report focuses on the effort to integrate SMF into the CSMP using the Contra Costa I-680 CSMP as the pilot evaluation for such a process.

APPROACH

The I-680 CSMP served as the pilot for implementing the Smart Mobility approach for a complex, congested urban freeway corridor. Compared to the previous, first generation CSMPs that were more freeway-centric, the SMF was integrated into the CSMP process to demonstrate a more comprehensive multi-modal scenario evaluation. Technical analyses of the first generation CSMPs focused on corridor performance using micro-simulation models. To carry out the analysis, the I-680 CSMP scope of work an dstudy consultant identified six tasks for the project as shown in Figure 2. Stakeholder engagement and

[1] System Metrics Group, Inc., Contra Costa County I680 Corridor System Management Plan (CSMP) Final Report, Executive Summary, July 8, 2014.

outreach programs were key components of the I-680 CSMP effort allowing for collaborative involvement of partners throughout the process.

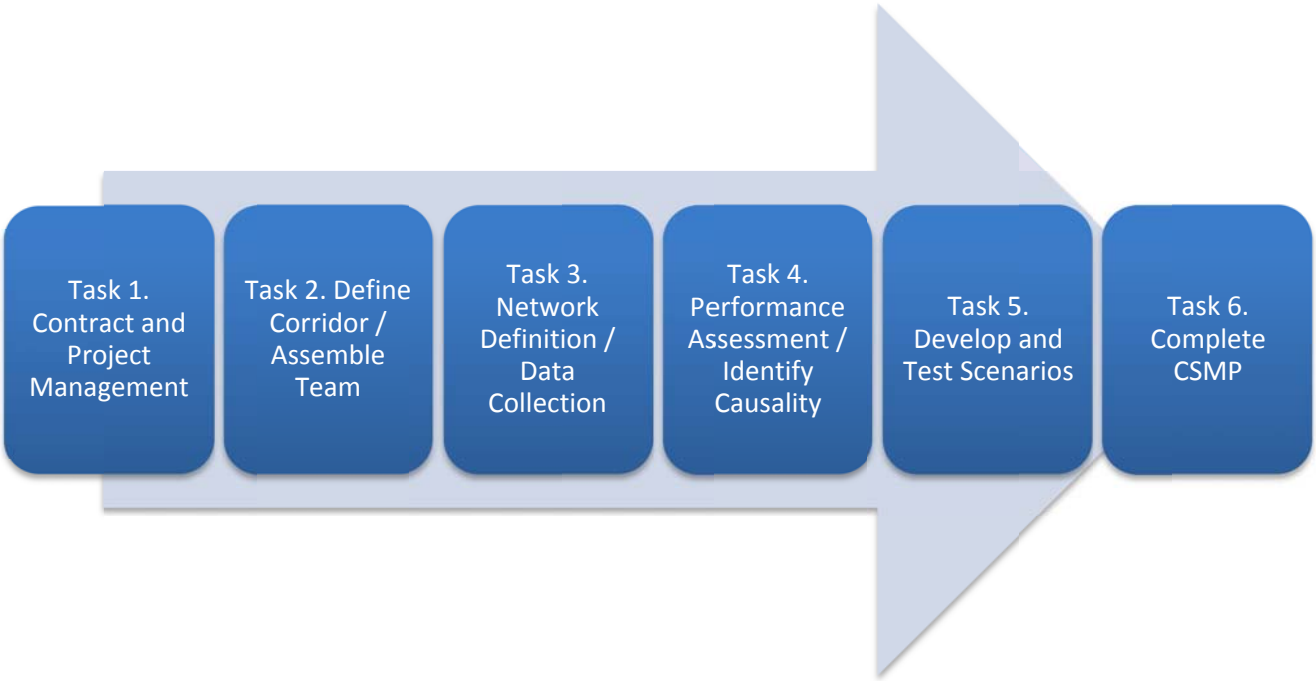


Figure 2. CSMP Work Scope Tasks

The SMF was integrated into several tasks during the planning process. Specifically, the SMF was integrated into the following tasks:

- Task 2. Corridor / Network Definition: Expanding the geographic study area and modal coverage to include transit, bikes, and pedestrians as well as autos. Review of SMF place types along the corridor.
- Task 3. Data Collection and Analysis: Review of all 17 SMF performance measures, data needs, and sources, assess data quality and availability, and assess available and alternative methodologies for analysis.
- Task 4. SMF Performance Assessment: Identify applicable SMF performance measures for application.
- Task 5. Test Scenarios: Identify strategies and solutions to improve performance from SMF perspective.

While the other components, e.g., TOPL and Stakeholder Outreach, were integral to the CSMP process, this report focuses on the integration of the SMF.

FINDINGS

SMF Place Types

The CSMP focuses on transportation and did not explore alternative land use scenarios along the study corridor limiting the application of SMF place types and SMF principles and performance measures that related to land use. The SMF place types were used to broadly categorize areas along the corridor in order to suggest appropriate transportation projects and programs to achieve Smart Mobility benefits. As part of the existing conditions assessment, the CSMP team conducted a very detailed analysis of land uses and transportation context for the study corridor. The analysis was done at the traffic analysis zone (TAZ) level to identify SMF place types.

Most of the corridor falls within the "suburban community" place type, which represents a low level of integration of housing with jobs, retail, and services, poor connectivity of the street network, and low levels of transit service. Downtown Walnut Creek and downtown Concord are leading candidates for multi-modal strategies as representatives of "urban center" place type. These communities have high levels of regional accessibility and higher density mixed use places. . The place types analysis served to be valuable in recognizing the differences in accessibility and design for these communities along the corridor, which can then be used to inform types of future improvements that best achieve smart mobility benefits.

SMF Performance Measures

The performance measures established for the CSMP are based on nine SMF performance measures. The process for identifying these performance measures is described as follows:

1. Review the 17 SMF performance measures to determine which apply to the CSMP.
2. Review literature and conduct interviews on best practices for corridor performance evaluation.
3. Review availability of data and tools for the SMF performance measures
4. Prioritize and identify the key SMF performance measures for this CSMP effort.

This prioritization effort is described in a memo entitled *Preliminary Performance Measures for the I-680 CSMP*, dated August 12, 2012. (See Appendix C.)

The selected performance measures are described in Figure 3. Each performance measure addresses a specific CSMP goal and potential data sources are listed.

Exhibit 4-2: Contra Costa County I-680 CSMP Performance Measures

Smart Mobility Framework (SMF) Performance Measure		CSMP Goal Addressed	Metric	Current Conditions	Forecasting	Potential Data sources
2	Transit Mode Share	Location Efficiency	% of non-SOV trips (includes carpool/vanpools)	Yes	Yes	CCTA model
4	Multi-Modal Travel Mobility	Reliable Mobility	Total user-hours of travel times and travel costs by mode for the corridor	Yes	Yes	PeMS, Tachometer Vehicle Runs, TOPL, CCTA model
			Congestion (Vehicle Hours of Delay) - Time Period - Month - Day of Week - Severity (at 60mph, 35mph) - Hour of Day - Bottleneck Locations & Severity	Yes	For average weekday modeled period	PeMS, TOPL
			Productivity - Lost Lane Miles - by Time of Day	Yes	No	PeMS
5	Multi-Modal Travel Time Reliability	Reliable Mobility	Travel time reliability measures by mode: buffer index, standard deviation; Travel time reliability relative to each mode	Yes	Yes	PeMS for baseline. Evaluating feasibility for forecasting
6	Multi-Modal Service Quality	Multimodal Level of Service	Level of Service (LOS)	Yes	Maybe (if forecast data available)	HCM 2010 MMLOS methodology data sources
		Complete Streets	Complete Streets Evaluation	Yes	No	Satellite imagery, field evaluation
		Sustainable Infrastructure	Pavement Condition - Distressed Lane-Miles - International Roughness Index	Yes	No	Caltrans Pavement Management System
7	Multi-Modal Safety	Health and Safety	Accidents/Accident Rates - by Mode - by Month - by Weekday/Weekend	Yes	No	TASAS, SWITRS, CCTA model, Highway Safety Manual, Caltrans Traffic Safety Index (from HSIP)
9	Pedestrian & Bicycle Mode Share	Health and Safety	Bicycle and pedestrian mode share in corridor	Yes	No	CCTA model, American Community Survey, National Household Travel Survey
10	Climate and Energy Conservation	Environmental Stewardship	VMT by speed range for the corridor	Yes	Yes	CCTA model
11	Emissions Reduction	Environmental Stewardship	Emissions by criteria pollutant	Yes	Yes	CCTA model, EMFAC
17	Return on Investment (ROI)	Robust Economy	Benefit-cost: Net present value of benefits (travel time, reliability) minus net present value of costs (capital, O&M, air pollution, crashes)	n/a	Yes	Results of previous performance measures (2, 4, 5, 7, 9, 10, and 11 above). Cal-B/C

Source: System Metrics Group, 2014.

Figure 3. CSMP Performance Measures

Analysis Results

Travel time reliability was applied as a performance measure in this CSMP to test corridor improvement scenarios. The methodology used to calculate reliability was jointly selected by the SMF consultant and the CSMP consultant based on available data and the latest research. This methodology was utilized in the scenario analysis. Given the data available, analysis tools, and selected methodology, travel time reliability results were not sensitive to differences among the scenarios studied. Travelers want travel time reliability to have consistency or dependability in travel times along the corridor. The SHRP 2

Reliability research is developing new methods for evaluating operations strategies to improve travel time reliability.

The multimodal LOS analysis and the Complete Streets Assessment were two different approaches to incorporating alternative modes of transit, bicycling, and walking into the corridor study. Each had the challenges of how to cover the entire study area given the resources allocated to cover this aspect. The multimodal LOS analysis applied the 2010 *Highway Capacity Manual* methodology to a select few locations on parallel arterials. Additional resources would need to be allocated to data collection for the arterials, including inputs to the bicycle and pedestrian LOS calculations. The Complete Streets Assessment segmented the corridor and included an inventory and identification of potential improvements to parallel and crossing facilities. In addition, the D4 Complete Streets Guidance on data collection and analysis provided guidance on how best to incorporate this type of analysis into the CSMP.

CHALLENGES

With the three new planning elements being introduced as part of the second generation CSMP, the SMG team was faced with many challenges of managing the expectations and possible limitations of the resources allocated to this effort. Specifically,:

- While TOPL could include the arterial streets, TOPL analysis was limited to freeway and first intersection due to resource and data constraints.
- Complete Street analysis was limited by the resources to be able to collect data for all modes within the study area that extended to parallel facilities within a two-mile buffer around the freeway corridor.
- MMLOS analysis provided one possible approach to capturing the interactions among modes and providing an understanding of some of the trade-offs associated with highway improvements and strategies, but the analysis was limited to a few select locations that did not engage local stakeholders in deciding which locations to analyze.

Limitations of the Tools

Contra Costa Transportation Authority Travel Demand Model

The interaction between land use and transportation was captured in the traffic forecasts using the CCTA travel demand model. As a traditional four-step model that uses the land use and socio-economic information and transportation systems as inputs to the trip generation, trip distribution, mode choice, and assignment, the CCTA model provided the forecasts of future demand on I680 and local streets and transit.

Given the scale (corridor level) and the available models (CCTA model vs. MTC regional model), the CCTA model was deemed the most appropriate for this study due to the additional network and zonal

detail along the analysis corridor. However, the model was in the process of being updated to more current land use assumptions to be consistent with the regional assumptions in the RTP/SCS.

While the CCTA model forecasted vehicular demand, alternative modes, such as bicycling and walking are not covered. Tools need to be more sensitive to active transportation modes.

Unlike the SMF place types analysis, which is based on the existing land use and accessibility to identify places that are more likely to benefit from smart mobility strategies, the CCTA model uses the existing and future land use and transportation system inputs to forecast the changes in traffic volumes and transit ridership.

Tools for Operational Planning (TOPL)

Some of the limitations of TOPL, which affected the schedule and outcomes include unexpected failure of significant blocks of corridor detection equipment from copper theft/vandalism and lack of timely replacement following construction activity, as well as high cost and time required to collect data for arterials to include in TOPL model.

Other

Timing was challenging due to late start for the SMF contract to be more fully integrated into the CSMP process. With the later start, the CSMP work plan was already completed several months prior to the refinement of the SMF work plan. This resulted in some complications with coordination between the two efforts at the start of the project.

Future land use alternatives were not considered as part of the scenario testing, which considered transportation projects and strategies. To understand the land use context, the SMF Place Types were identified based on the existing and future land use information by traffic analysis zone in the travel demand model.

CONCLUSIONS AND RECOMENDATIONS

Place Types

Given the objectives of the CSMP, modifications to land uses along the corridor as part of the scenario testing were not considered to be appropriate. Land use changes as part of the scenario testing would involve a broader stakeholder group and would be more appropriate as part of a corridor specific plan or area plan.

Recommendations:

- Apply SMF place types to incorporate land use context into transportation decision-making, specifically when identifying and prioritizing transportation projects and programs.

- Conduct a pilot study in a suburban or rural community area to test how SMF would apply in "suburban community" place types with poor street connectivity and limited transit options.

Performance Measures

Selecting Performance Measures

The SMF allowed the team to choose from existing performance metrics with readily available data to fill in as many of the 17 performance measures as possible. In the case of the I-680 CSMP, the selection was based on the available data and models as well as the study objectives.

Recommendation:

- Provide guidance on selecting performance measures based on the approaches used in PA1.

Reliability

Given the interest in the predictability in travel time, utilize travel time reliability as a performance measure for corridor management. While the on-going research focuses on travel time reliability for autos, reliability needs to include all modes, particularly, on urban arterials.

Recommendation:

- Identify latest research and best practices in reliability
  - Utilize available data sets and identify gaps for additional data collection
  - Review tools available or under development
- Incorporate availability of data, such as PeMs, InRIX, BlueMAC, etc, to support new models and methodologies for calculating reliability.

Multimodal Evaluation

Both the 2010 HCM multimodal LOS analysis and the Complete Streets Assessment had the challenges of how to cover the entire I-680 study area given the resources allocated to cover this aspect.

Recommendation:

- Additional resources would need to be allocated to data collection for the arterials, including inputs to the bicycle and pedestrian LOS calculations.
- In addition, the D4 Complete Streets Guidance on data collection and analysis could provide more guidance on how best to incorporate this type of analysis into the CSMP.

Data Needs

Arterial Analysis

With the three new planning elements being introduced as part of the second generation CSMP, the SMG team was faced with many challenges of managing the expectations and possible limitations of the resources. Multimodal LOS was useful as tool to understand trade-offs among modes, but the cost to perform MMLOS analysis for all parallel arterials in the study area would be high compared to the added value to the CSMP effort.

Recommendations:

- Continue to expand freeway detection along the I 680 corridor to continually monitor to track changes in performance.
- Collect dataset on arterials to allow for TOPL analysis or other arterial analysis, such as MMLOS.
- Incorporate new data sources.
- Focus the MMLOS on specific segments or locations within the study area based on stakeholder input.

Tools

Choosing an analysis tool, or package of tools, was a very challenging exercise. Existing tools are being expanded and upgraded, while new tools are being developed. Over the course of the pilot study, the tool inventory changed significantly, and a tool selection process performed at the end of the study would likely have yielded a different choice than it did at the beginning.

CCTA Model

The interaction between land use and transportation was captured in the traffic forecasts using the CCTA travel demand model. The CCTA model uses the existing and future land use and transportation system inputs to forecast the changes in traffic conditions and transit ridership.

Recommendation:

- Develop post-model tools that interface with the travel demand models or sketch models to better capture the land use and transportation interactions.

TOPL

Some of the limitations of TOPL, which affected the schedule and outcomes include unexpected failure of significant blocks of corridor detection equipment from copper theft/vandalism and lack of timely replacement following construction activity, as well as high cost and time required to collect data for arterials to include in TOPL model.

Recommendation:

- Support additional research in development of TOPL tool, possibly leveraging new data sources that have become available on local roadways.

Section 2
Introduction

INTRODUCTION

This report documents efforts over the past 18 months to integrate into local planning processes the California Department of Transportation's (Caltrans') groundbreaking report, *Smart Mobility 2010: A Call to Action for the New Decade*, which defines a vision for developing a new approach to transportation that is multimodal, sustainable and integrated with land use. The Smart Mobility Framework (SMF) principles were applied as a broad framework to identify an approach and strategies for considering SMF performance measures when evaluating future multi-modal and sustainable corridor scenarios. The report describes results and recommendations for integrating Smart Mobility concepts as well as broader performance measures (identified during this study) into the Corridor System Management Plan (CSMP) development process.

BACKGROUND

In February 2010, Caltrans released *Smart Mobility 2010: A Call to Action for the New Decade*. This document provides a broad planning framework to help guide multi-modal and sustainable transportation planning and development along with providing tools and techniques to assess how well plans, programs, and projects meet 'smart mobility' goals throughout the state.

> *Smart Mobility moves people and freight while enhancing California's economic, environmental, and human resources by emphasizing convenient and safe multi-modal travel, speed suitability, accessibility, management of the circulation network, and efficient use of land.*

The SMF consists of the following principles, place types, and performance measures:

- Six (6) Smart Mobility Principles that express the priorities and values of Smart Mobility
    - Location Efficiency
    - Reliable Mobility
    - Health and Safety
    - Environmental Stewardship
    - Social Equity
    - Robust Economy
- Seven (7) Smart Mobility Place Types designed as tools for planning and programming that implement Smart Mobility:
    - Urban Centers
    - Close-in Compact Communities
    - Compact Communities
    - Suburban Areas
    - Rural and Agricultural Lands

  - Protected Lands
  - Special Use Areas

- Seventeen (17) Smart Mobility Performance Measures that relate to the six (6) Principles (as shown in Table 1)

Table 1. Smart Mobility Principles and Performance Measures

Principle	Performance Measure
Location Efficiency	1. Support for Sustainable Growth
	2. Transit Mode Share
	3. Accessibility and Connectivity
Reliable Mobility	4. Multi-Modal Travel Mobility
	5. Multi-Modal Travel Reliability
	6. Multi-Modal Service Quality
Health and Safety	7. Multi-Modal Safety
	8. Design and Speed Suitability
	9. Pedestrian and Bicycle Mode Share
Environmental Stewardship	10. Climate and Energy Conservation
	11. Emissions Reduction
Social Equity	12. Equitable Distribution of Impacts
	13. Equitable Distribution of Access and Mobility
Robust Economy	14. Congestion Effects on Productivity
	15. Efficient Use of System Resources
	16. Network Performance Optimization
	17. Return on Investment

Source: Caltrans. *Smart Mobility 2010: A Call to Action for the New Decade*, Exhibit 10, p. 51.

This effort is part of a larger study being conducted for Caltrans Headquarters Division of Transportation Planning, Office of Sustainable Community Planning Office to test implementation of the SMF into current transportation planning processes. Specifically, this Pilot Area 1 (PA1) involved integrating SMF principles and performance measures into a second generation Corridor System Management Plan (CSMP) for the I-680 corridor within Contra Costa County in Caltrans District 4. This PA1 study was intended to be supplementary and complementary to the CSMP process. For Pilot Area 2 (PA2), the goal was to develop a suite of easy-to-use processes and tools to apply Caltrans' SMF toward best practices for sub-regional planning products, project analysis, and ultimately, infrastructure decision making. The results of these two pilot area studies will be shared with Caltrans, agency partners, and other stakeholders.

Second Generation CSMP

The CSMP effort for I-680 in Contra Costa County leveraged and coordinated resources from related efforts to advance the state-of-practice in corridor-wide system planning, operations analysis, and system management. As such, the effort included a demonstration of the Tools for Operations Planning (TOPL) corridor analysis tool as well as the application of the Smart Mobility Framework in this *second generation* CSMP. As noted in the RFO for the I-680 CSMP:

> "The main emphasis of the *second generation* CSMP is to expand on corridor performance analysis by using TOPL and SMF tools and performance measures to produce a more multi-modal, comprehensive, joint system management plan for a corridor in D4. The outcome of the I-680 CSMP is to provide project and strategy recommendations to inform the regional transportation planning process, provide a 25-year facility concept for the Department and provide a foundation for ongoing system monitoring."

This innovative approach will be considered for other congested corridors in D4 needing CSMP-level analysis. The approach could also be applied to other corridors statewide.

SCOPE OF THE REPORT

The Contra Costa County Interstate 680 (I-680) Corridor System Management Plan (CSMP) is the first *second generation* CSMP in the state. Previous CSMP efforts presented an analysis of existing and future traffic conditions and proposed traffic management strategies and transportation improvements to maintain and enhance mobility for specific segments of the most congested corridors in District 4. As a second generation CSMP, this effort also incorporates three new planning elements:

- Tools for Operational Planning (TOPL) – As a new tool being developed by the University of California at Berkeley's Partners for Advanced Transportation Technology (PATH) program, the CSMP was the first large-scale demonstration of the TOPL tool.
- Smart Mobility Framework (SMF) – Elements of the SMF, such as the principles, place types, and performance measures, were incorporated throughout the planning process.

- Complete Streets – In response to the state's Complete Streets Act of 2008 and Caltrans' *Deputy Directive-64-R2,*[2] evaluation and provisions for safe mobility of all users, including transit riders, bicyclists, and pedestrians, were included.

The Contra Costa I-680 CSMP Final Report[3] and the accompanying Executive Summary[4] presents and summarizes the effort.

This report focuses on the effort to integrate SMF into a more comprehensive corridor management plan using the Contra Costa I-680 CSMP as the pilot evaluation for such a process.

[2] Deputy Directive 64 was reaffirmed on October 17, 2014. While there were no changes to the directive itself, DD-64-R2 reflects Caltrans' commitment to Complete Streets.

[3] System Metrics Group, Inc., Contra Costa County I680 Corridor System Management Plan (CSMP) Final Report, August 15, 2014.

[4] System Metrics Group, Inc., Contra Costa County I680 Corridor System Management Plan (CSMP) Final Report, Executive Summary, July 8, 2014.

Section 3
Approach

APPROACH

The I-680 CSMP served as the pilot for implementing the Smart Mobility approach for a complex, congested urban freeway corridor. Compared to the previous, first generation CSMPs that were more freeway-centric, the SMF was integrated into the CSMP process to demonstrate a more comprehensive multi-modal scenario evaluation. Technical analyses of the first generation CSMPs focused on corridor performance using micro-simulation models. To carry out the analysis, the I-680 CSMP scope of work and study consultant identified six tasks for the project as shown in Figure 4.

A key component of the I-680 CSMP effort was a stakeholder engagement and outreach program that allows for collaborative involvement of partners throughout the process.

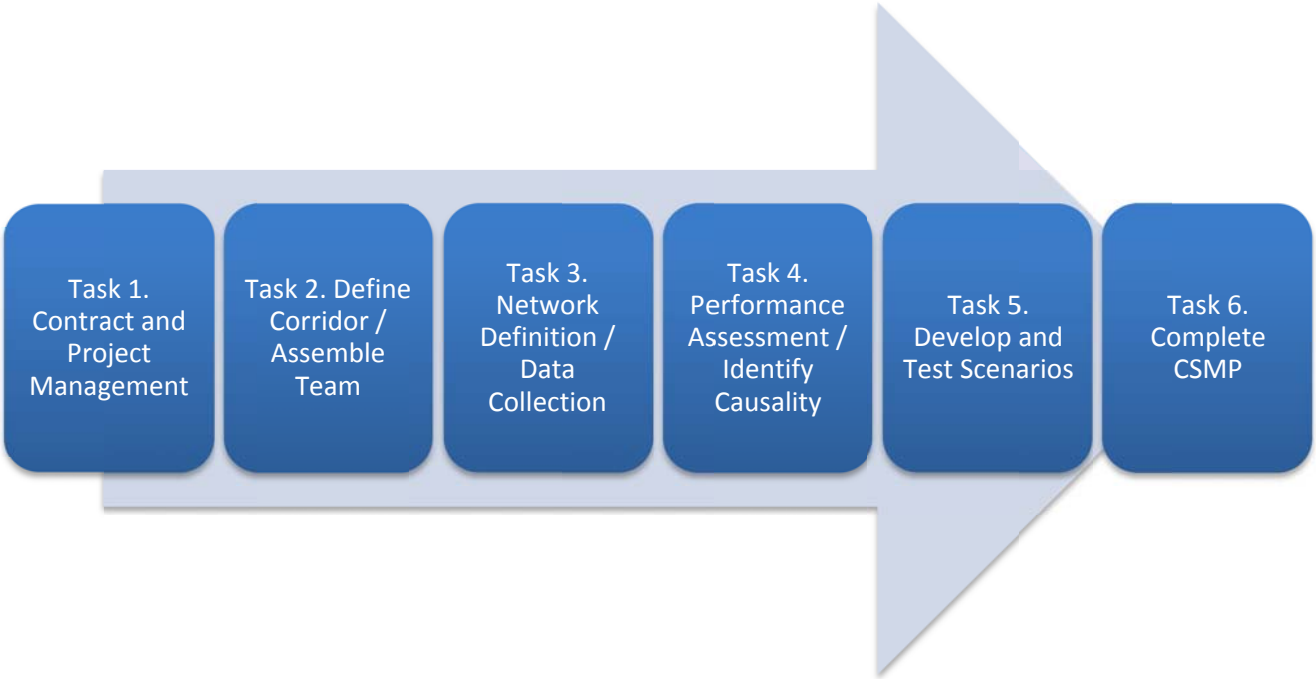


Figure 4. CSMP Work Scope Tasks

The SMF was integrated into several tasks during the planning process. Specifically, the SMF place types, principles, and performance measures were integrated into the following tasks:

- Task 2. Corridor / Network Definition: Expanding the geographic study area and modal coverage to include transit, bikes, and pedestrians as well as autos. Review of SMF place types along the corridor.
- Task 3. Data Collection and Analysis: Review of all 17 SMF performance measures, data needs, and sources, assess data quality and availability, and assess available and alternative methodologies for analysis.
- Task 4. SMF Performance Assessment: Identify applicable SMF performance measures for application.

- Task 5. Test Scenarios: Identify strategies and solutions to improve performance from SMF perspective.

While the other components, e.g., TOPL and Stakeholder Outreach, were integral to the CSMP, this report focuses on the integration of the SMF.

SMF PILOT AREA 1 WORK PLAN

As part of the SMF study, a detailed work plan was prepared for Pilot Area 1 (PA1). Based on input received from Caltrans District 4 (as the Pilot Area Sponsor) and the CSMP consultant, the scope of work was refined.

Due to the three month difference between the kick-off for the CSMP study and when the SMF team was engaged and, a high priority was to coordinate project schedules. At the start of the SMF contract, the Staff Working Group (AWG) and the Technical Advisory Committee (TAC) members had already been identified and a schedule for SWG meetings was already established.

The coordination with the CSMP effort was only a part of the overall scope of work for the SMF study, as shown in Figure 5, which included a literature review (Task 3), evaluation of the two pilot area studies (Task 6) and recommendations for future implementation of the SMF (Task 7).

The purpose of the literature review (Task 3) was to identify subject matter experts and literature review sources to interview and review regarding leading edge sustainable and multi-modal transportation planning practices, building upon related research efforts conducted for Caltrans as a Preliminary Investigation (dated April 25, 2012)[5] and focusing on developments in research, guidance, performance measures and tools released or under development since the February 2010 release of the Smart Mobility 2010: Call to Action. The "practice in progress" review was coordinated with the follow-up preliminary investigation that was produced by the Institute of Transportation Studies

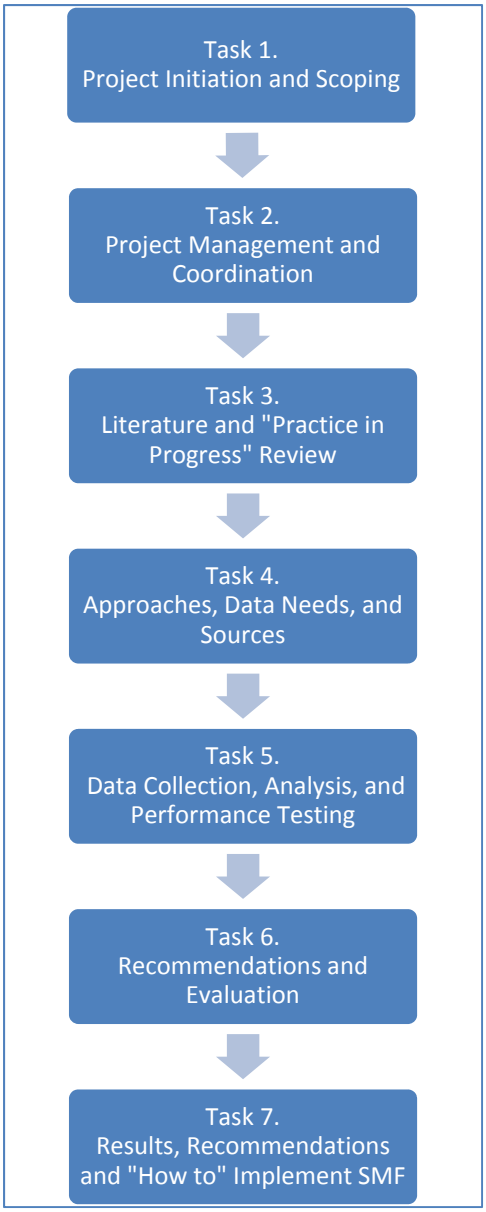


Figure 5. Scope of Work for SMF Study

[5] Caltrans Division of Research and Innovation. Preliminary Investigation, Smart Mobility: A Survey of Current Practice and Related Research, Produced by CTC & Associates, LLC, April 25, 2012.

Library at UC Berkeley.[6] This review focused on corridor planning performance measures, tools and data, since the Pilot Area 1 effort preceded the Pilot Area 2 effort .

As part of analysis (Task 5), the SMF work plan included a Complete Street Assessment applying the 2010 Highway Capacity Manual Multi-modal LOS (MMLOS) methodologies. This effort was in addition to the Complete Street Assessment that was conducted by Nelson-Nygaard as part of the CSMP effort. The purpose of the MMLOS analysis was to evaluate the interactions among modes and better understand the trade-offs among modes. Specifically, MMLOS is a tool to understand if and how recommendations to improve traffic flow and reduce delays along I680 could affect other modes that share the parallel arterials and interface with the traffic at interchanges.

The detailed work plan for the PA1 effort is provided in Appendix A.

[6] Caltrans, Division of Research and Innovation. Smart Mobility Preliminary Investgation, November 15, 2012.

Section 4
Findings and Challenges

FINDINGS AND CHALLENGES

FINDINGS

The summary and findings from the Contra Costa I-680 CSMP are presented in the Contra Costa I-680 CSMP Final Report[7] and the accompanying Contra Costa I-680 CSMP Executive Summary[8]. The key findings as they relate to the integration of the SMF into the second generation CSMP are described below.

SMF Place Types

The CSMP focuses on transportation and did not explore alternative land use developments along the study corridor limiting the application of SMF place types and SMF principles and performance measures that relate to land use. However, the SMF place types were used to broadly categorize areas along the corridor in order to suggest appropriate transportation projects and programs to achieve Smart Mobility benefits.

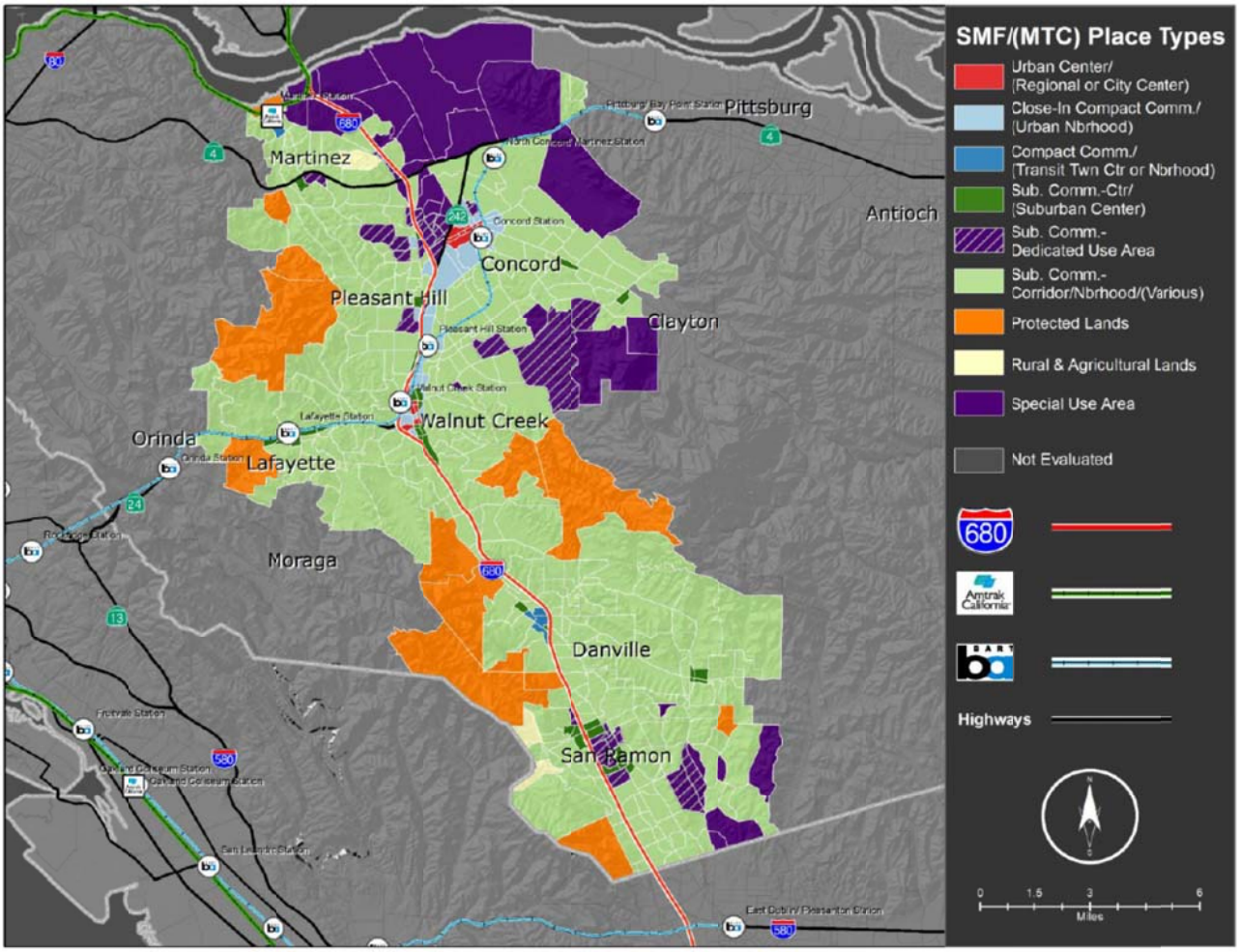
The CSMP team conducted a very detailed analysis of land uses and transportation context for the study corridor as part of the existing conditions assessment. The analysis was done at the traffic analysis zone (TAZ) level to identify SMF place types. The results of the SMF place type analysis for the I-680 corridor are shown in Figure 6. The memo documenting the analysis approach and results is provided in Appendix B.

Most of the corridor falls within the "suburban community" place type, which represents a low level of integration of housing with jobs, retail, and services, poor connectivity of the street network, and low levels of transit service. Downtown Walnut Creek and downtown Concord are leading candidates for multi-modal strategies as representatives of the "urban center" place type. These communities have high levels of regional accessibility and higher density mixed use places making them

[7] System Metrics Group, Inc., Contra Costa County I680 Corridor System Management Plan (CSMP) Final Report, June 23, 2014.

[8] System Metrics Group, Inc., Contra Costa County I680 Corridor System Management Plan (CSMP) Final Report, Executive Summary, July 8, 2014.

Figure 6. SMF Place Types



Source: System Metrics Group, Inc., I-680 Corridor System Management Plan Smart Mobility Framework (SMF) Place Type Analysis Methodology, August 3, 2012.

SMF Performance Measures

The performance measures established for the CSMP are based on nine SMF performance measures. The process for identifying these performance measure is described as follows:

1. Review the 17 SMF performance measures to determine which might apply to the CSMP goals.
2. Review literature and conduct interviews on best practices for corridor performance evaluation.
3. Review availability of data and tools for the SMF performance measures
4. Prioritize and identify the key SMF performance measures for this CSMP effort.

This prioritization effort is described in a memo entitled *Preliminary Performance Measures for the I-680 CSMP*, dated August 12, 2012. (See Appendix C.)

The selected performance measures are described in Figure 7. Each performance measure addresses a specific CSMP goal, then one or more metric was identified that could be used to evaluate existing or forecast conditions and potential data sources are listed.

Exhibit 4-2: Contra Costa County I-680 CSMP Performance Measures

Smart Mobility Framework (SMF) Performance Measure		CSMP Goal Addressed	Metric	Current Conditions	Forecasting	Potential Data sources
2	Transit Mode Share	Location Efficiency	% of non-SOV trips (includes carpool/vanpools)	Yes	Yes	CCTA model
4	Multi-Modal Travel Mobility	Reliable Mobility	Total user-hours of travel times and travel costs by mode for the corridor	Yes	Yes	PeMS, Tachometer Vehicle Runs, TOPL, CCTA model
			Congestion (Vehicle Hours of Delay) - Time Period - Month - Day of Week - Severity (at 60mph, 35mph) - Hour of Day - Bottleneck Locations & Severity	Yes	For average weekday modeled period	PeMS, TOPL
			Productivity - Lost Lane Miles - by Time of Day	Yes	No	PeMS
5	Multi-Modal Travel Time Reliability	Reliable Mobility	Travel time reliability measures by mode: buffer index, standard deviation; Travel time reliability relative to each mode	Yes	Yes	PeMS for baseline. Evaluating feasibility for forecasting
6	Multi-Modal Service Quality	Multimodal Level of Service	Level of Service (LOS)	Yes	Maybe (if forecast data available)	HCM 2010 MMLOS methodology data sources
		Complete Streets	Complete Streets Evaluation	Yes	No	Satellite imagery, field evaluation
		Sustainable Infrastructure	Pavement Condition - Distressed Lane-Miles - International Roughness Index	Yes	No	Caltrans Pavement Management System
7	Multi-Modal Safety	Health and Safety	Accidents/Accident Rates - by Mode - by Month - by Weekday/Weekend	Yes	No	TASAS, SWITRS, CCTA model, Highway Safety Manual, Caltrans Traffic Safety Index (from HSIP)
9	Pedestrian & Bicycle Mode Share	Health and Safety	Bicycle and pedestrian mode share in corridor	Yes	No	CCTA model, American Community Survey, National Household Travel Survey
10	Climate and Energy Conservation	Environmental Stewardship	VMT by speed range for the corridor	Yes	Yes	CCTA model
11	Emissions Reduction	Environmental Stewardship	Emissions by criteria pollutant	Yes	Yes	CCTA model, EMFAC
17	Return on Investment (ROI)	Robust Economy	Benefit-cost: Net present value of benefits (travel time, reliability) minus net present value of costs (capital, O&M, air pollution, crashes)	n/a	Yes	Results of previous performance measures (2, 4, 5, 7, 9, 10, and 11 above). Cal-B/C

Source: System Metrics Group, 2014.

Figure 7. CSMP Performance Measures

Results

The PA1 I-680 CSMP scenarios, projects, and results of the analysis are summarized in Figure 8.

Exhibit 9-1: I-680 CSMP Scenarios, Projects, and Results

Scenario	Scenario Description	Scenario Projects	Mobility– Average Weekday VHD (1000s)	Reliability– I-680 Highest Travel Time Index	Emissions– Average Daily Short Tons	B/C Ratio
2010 Base	CCTA 2010 Base Year model with no scenario projects included		33	1.4	4,170	n/a
2030 Base	CCTA 2030 Constrained Plan Travel Demand Model results with programmed/planned scenario projects removed for the analysis		87	1.5	5,250	n/a
S1 (2030)	Most near-term (≤ 5 years), fully funded, programmed mobility-related projects on or near I-680. Evaluated using the 2010 and 2030 models.	• Arterials: Buskirk & Contra Costa Blvd. widening • Aux Lanes: Sycamore Valley Rd.-Crow Canyon Rd. • Express Lanes: Extend north to Livorna Rd.	83	1.5	5,175	8.6
S2 (2030)	Other near-term operational projects Scenario 2a tests ramp metering alone to isolate its impacts. S2a tested only with TOPL (when available) Scenario 2b includes other operational strategies likely to be completed in the near future. Evaluated using the 2010 and 2030 models.	• Express Lanes: NB Main St-SR-242 • Express Lanes: SB Marina Vista Ave-Livorna Rd (includes SB HOV gap closure) • HOV direct access ramps (unspecified location in San Ramon area) • I-680/SR-4 interchange improvements (Phase 3)	78	1.5	5,150	1.0
S3 (2030)	Other programmed or fully committed projects to be delivered ≥5 years. Evaluated using the 2030 model.	• Arterial Improvements: Contra Costa & Pacheco Blvds. • I-680/SR-4 interchange improvements (Phases 1,2,4,5)	78	1.5	5,150	2.1
S4 (2030)	Long-term potential auxiliary lane additions that have been presented in other long-range planning reports. Evaluated using the 2030 model.	• Alcosta Rd. to Bollinger Canyon Rd. • El Cerro Rd. to El Pintado Rd. • El Pintado Rd. to Stone Valley Rd. • Stone Valley Rd. to Livorna Rd. • Livorna Rd. to Rudgear Rd.	73	1.5	5,100	17.2
S5 (2030)	Trip-making reduced by 1.5% per day due to bicycle/pedestrian improvements. Reduction based on analysis from Appendix A: Bicycle Demand Forecasting of the *2009 Contra Costa Countywide Bicycle and Pedestrian Plan*. Evaluated using the 2030 model.		73	1.5	5,075	10.1

Change relative to prior scenario: Increases Decreases No Change

System Metrics Group, Inc.

Source: System Metrics Group. I-680 CSMP Final Report, August, 2014.

(Note: These results were prepared prior to the completion of the TOPL analysis. For final results of the CSMP, see the Final CSMP Report as finalized in February 2015.)

Figure 8. PA1 I-680 CSMP Scenarios, Projects, and Results

The relative changes are indicated by the arrows and occur when compared to a previous scenario for the key metrics of vehicle hours of delay (VHD), reliability, emissions, and benefit-cost ratio (B/C ratio). The last scenario (Scenario 5) assumes bicycle and pedestrian improvements along the corridor based on the *2009 Contra Costa Bicycle and Pedestrian Plan*.

Travel Time Reliability

Travel time reliability was applied as a performance measure in this CSMP to test corridor improvement scenarios. The methodology used to calculate reliability was jointly selected by both the SMF consultant and the CSMP consultant based on available data and the latest research. Research on travel time reliability has been predominantly concerned with highway travel time reliability, most recently the Strategic Highway Research Program (SHRP). While tools are available to forecast travel time reliability for auto travel, similar tools for forecasting reliability for other travel modes is still lacking.

Auto travel time reliability can be estimated from the models developed as part of the SHRP 2 L03 study: Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies. The project produced two sets of models for estimating travel time reliability:

- "data poor" models are for situations where available data are limited; these are parsimonious models that rely on travel time index alone
- "data rich" models can be applied where the necessary forecast data are available; these include demand/capacity on the critical segment along a corridor, lane hours lost due to non-recurrent events, and rainfall

Details of the predictive models can be found in chapter 7 the final report for the project.[9] For freeways the use of the "data rich" models was recommended. However, given some of the data limitations, assumptions were made regarding rainfall and incident clearance times. Additional details can be found in the Appendix C.

Given the data available, analysis tools, and selected methodology, the results show that travel time reliability as a performance measure was not sensitive to differences among the scenarios studied. Travelers want travel time reliability to have consistency or dependability in travel times along the corridor. The SHRP 2 Reliability research is developing new methods for evaluating operations strategies to improve travel time reliability.

Multimodal Evalutions

The multimodal LOS analysis and the Complete Streets Assessment were two different approaches to incorporating alternative modes of transit, bicycling, and walking into the corridor study. Each had the

[9] Cambridge Systematics. SHRP 2 Project L03: Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies. September 2011.

challenges of how to cover the entire study area given the resources allocated to cover this aspect. The multimodal LOS analysis applied the 2010 *Highway Capacity Manual* methodology to a seven roadway segments on parallel arterials based on available count data. Additional data for the MMLOS was collected using aerial surveys from Google maps, bus schedules, and limited field visits. The analysis focused on one period (AM or PM) and one direction of travel. The methodology reports a grade for the roadway as signalized intersections and links representing the roadway between two signalized intersections as well as the segment. The methodology also combines the intersection and link LOS scores with additional factors, such as the number of access points. The methodology provides a grade for transit for the entire segment, rather than analyzing transit service at the intersection or link levels. The approach and results of this MMLOS analysis is documented in Appendix D. Additional resources would need to be allocated to data collection for the arterials, including inputs to the bicycle and pedestrian LOS calculations.

The Complete Streets evaluation applied a preliminary approach as part of the CSMP with the goal of ensuring that improvements on the corridor also address the ability of bicyclists and pedestrians to move safely across and along the I-680 freeway corridor in Contra Costa County. The approach included cataloguing infrastructure details to identify improvement opportunities and prioritize recommendations. The facilities identified for evaluation include crossings or transverse routes as well as parallel routes or alternatives to the freeway corridor. The presence or absence of essential features was evaluated for each facility type. First, the needs were prioritized based on crossing frequency and presence of parallel alternatives, then improvements for bicyclists and pedestrians were identified for locations with the greatest need.

In addition, the D4 Complete Streets Guidance on data collection and analysis provided more guidance on how best to incorporate this type of analysis into the CSMP.

CHALLENGES

With the three new planning elements being introduced as part of the second generation CSMP, the SMG team was faced with many challenges of managing the expectations and possible limitations of the resources allocated to this effort. Specifically,:

- While TOPL could include the arterial streets, TOPL analysis was limited to freeway and first intersection due to resource and data constraints.
- Complete Street analysis was limited by the resources to be able to collect data for all modes within the study area that extended to parallel facilities within a two-mile buffer around the freeway corridor.
- MMLOS analysis provided one possible approach to capturing the interactions among modes and providing an understanding of some of the trade-offs associated with highway improvements and strategies, but the analysis was limited to a few select locations that did not engage local stakeholders in deciding which locations to analyze.

Limitations of the Tools

CCTA Model

The interaction between land use and transportation was captured in the traffic forecasts using the CCTA travel demand model. As a traditional four-step model that uses the land use and socio-economic information and transportation systems as inputs to the trip generation, trip distribution, mode choice, and assignment, the CCTA model provided the forecasts of future demand on I680 and local streets and transit. Given the scale (corridor level) and the available models (CCTA model vs. MTC regional model), the CCTA model was deemed the most appropriate for this study due to the additional network and zonal detail along the analysis corridor. However, the model was in the process of being updated to more current land use assumptions to be consistent with the regional assumptions in the RTP/SCS.

Unlike the SMF place types analysis, which is based on the existing land use and accessibility to identify places that are more likely to benefit from smart mobility strategies, the CCTA model uses the existing land use and transportation system inputs to forecast the changes in traffic volumes and transit ridership.

TOPL

Some of the limitations of TOPL, which affected the schedule and outcomes include unexpected failure of significant blocks of corridor detection equipment from copper theft/vandalism and lack of timely replacement following construction activity, as well as high cost and time required to collect data for arterials to include in TOPL model.

Other

Timing was challenging due to late start for the SMF contract to be more fully integrated into the CSMP process. With the later start, the CSMP work plan was already completed several months prior to the refinement of the SMF work plan. This resulted in some complications with coordination between the two efforts at the start of the project.

Land use changes were not considered as part of the scenario testing, which focused on transportation improvements to address the congestion and improve operations on the freeway corridor. Rather the SMF Place Types were analyzed based on existing land use and accessibility. Potential areas of land use change and thus growth in future travel was captured in the CCTA model, but the scenario testing did not consider changes to future land use assumptions from that already assumed in the model.

Section 5
Conclusions and Recommendations

CONCLUSIONS AND RECOMMENDATIONS

The Smart Mobility Framework can be implemented into current transportation planning practices through varied approaches depending upon the type of study, regional/local context, and study objectives. Through the pilot area study, several barriers and challenges were identified. This section presents the barriers and challenges and provides recommendations to address them in future SMF implementation efforts.

PLACE TYPES

Place types are an important part of the SMF as they help to determine the existing and ideal characteristics of the transportation system and the thresholds that the system's performance should be achieving.

The SMF place types can be used to identify transportation projects and programs that should be considered as priorities. Selecting the identified projects can increase the presence of location efficiency factors, which connect the transportation system to land-use, yielding Smart Mobility benefits. The SMF place types are categorized based on intersect of regional accessibility and community design.

While the I-680 CSMP focused on transportation improvements and strategies, the place type analysis can help to identify the growth areas within the study area to prioritize the segments along a corridor that may be most impacted in the future as well as prioritize certain types of transportation improvements. Most of the I-680 corridor falls within the "suburban community" place type, which presents a challenge in achieving Smart Mobility benefits due to the low level of integration of housing with jobs, retail, and services, poor connectivity of the street network, and low levels of transit service.

Recommendations:

- Apply SMF place types to incorporate land use context into transportation decision-making, specifically when identifying and prioritizing transportation projects and programs.
- Conduct a pilot study in a suburban or rural community area to test how SMF would apply in "suburban community" place types with poor street connectivity and limited transit options.

PERFORMANCE MEASURES

Selecting Performance Measures

The 17 SMF performance measures are purposefully vague regarding the specific metric used to measure them. The PA1 study was able to implement a subset of the 17 smart mobility measures due to limited availability of data. The SMF allowed the team to choose from existing performance metrics with readily available data to fill in as many of the 17 performance measures as possible. In the case of

the I-680 CSMP, the selection was based on the available data and models as well as the study objectives.

Recommendation:

- Provide guidance on selecting performance measures based on the approaches used in PA1.

Reliability

Given the interest in the predictability in travel time, utilize travel time reliability as a performance measure for corridor management. Given the data available, analysis tools, and selected methodology, travel time reliability as a performance measure for I-680 was not sensitive to differences among the scenarios. This result could be attributed to the methodology, which required assumptions regarding incident clearance times and weather that were held constant across all scenarios, as well as the scenarios being tested, which did not include incident management strategies.

While the on-going research focuses on travel time reliability for autos, reliability needs to include all modes, particularly, on urban arterials.

Recommendation:

- Identify latest research and best practices in reliability
    - Utilize available data sets and identify gaps for additional data collection
        - FHWA National Performance Management Research Data Set
    - Review tools available or under development
        - University of Florida/FDOT spreadsheet
        - SHRP2-C11 Model
        - HCM 2010 Update (available in 2 years)
- Incorporate availability of data, such as PeMs, InRIX, BlueMAC, etc, to support new models and methodologies for calculating reliability.

Multimodal Evaluation

Both the 2010 HCM multimodal LOS analysis and the Complete Streets Assessment had the challenges of how to cover the entire I-680 study area given the resources allocated to cover this aspect.

Recommendation:

- Additional resources would need to be allocated to data collection for the arterials, including inputs to the bicycle and pedestrian LOS calculations.
- In addition, the D4 Complete Streets Guidance on data collection and analysis could provide more guidance on how best to incorporate this type of analysis into the CSMP.

DATA NEEDS

Arterial Analysis

With the three new planning elements being introduced as part of the second generation CSMP, the SMG team was faced with many challenges of managing the expectations and possible limitations of the resources allocated to this effort to evaluate the arterials and local streets, particularly for alternative modes. Specifically,:

- While TOPL could include the arterial streets, TOPL analysis was limited to freeway and first intersection due to resource and data constraints.
- Since the Complete Streets analysis was intended as a low resource approach for a high-level planning effort, the data collection and inventory was focused on parallel facilities within a two-mile buffer around the freeway corridor.
- MMLOS analysis provided one possible approach to capturing the interactions among modes and providing an understanding of some of the trade-offs associated with highway improvements and strategies.

The locations for the MMLOS analysis was limited to those intersections (and the upstream roadway) where traffic counts were available. Comments received from the TAC included the desire to have the selected segment reflect the input from local jurisdiction to determine where the spot analysis would be most informative.

Recommendations:

- Continue to expand freeway detection along the I 680 corridor to continually monitor to track changes in performance.
- Collect dataset on arterials to allow for TOPL analysis or other arterial analysis, such as MMLOS.
- Incorporate new data sources.
- Focus the MMLOS on specific segments or locations within the study area based on stakeholder input.

TOOLS

Choosing an analysis tool, or package of tools, was a very challenging exercise. There are many tools with different capabilities, customizability, licensing, and transparency. It was necessary to balance the desire for a tool that is familiar to the local and regional agencies with the need to have a tool that is

versatile enough to capture the benefits provided by different types of projects using smart mobility performance measures. The search for the ideal tool is further complicated by the fast paced evolution of the available tool set. Existing tools are being expanded and upgraded, while new tools are being developed. Over the course of the pilot study, the tool inventory changed significantly, and a tool selection process performed at the end of the study would likely have yielded a different choice than it did at the beginning.

CCTA Model

The interaction between land use and transportation was captured in the traffic forecasts using the CCTA travel demand model. The CCTA model forecasts traffic and transit ridership based inputs of land use and socio-economic data, specifically, households, household population, employed residents, and employment by sector. The number of trips generated by these households and employment is then estimated based on the proximity of adjacent uses and the distance between traffic analysis zones (TAZs) using the roadway network.

Unlike the SMF place types analysis, which is based on the existing land use and accessibility to identify places that are more likely to benefit from smart mobility strategies, the CCTA model uses the existing and future land use and transportation system inputs to forecast the changes in traffic conditions and transit ridership.

Recommendation:

- Develop post-model tools that interface with the travel demand models or sketch models to better capture the land use and transportation interactions.

TOPL

Some of the limitations of TOPL, which affected the schedule and outcomes include unexpected failure of significant blocks of corridor detection equipment from copper theft/vandalism and lack of timely replacement following construction activity, as well as high cost and time required to collect data for arterials to include in TOPL model.

Recommendation:

- Support additional research in development of TOPL tool, possibly leveraging new data sources that have become available on local roadways.

Section 6
References

REFERENCES

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2. Caltrans. *Smart Mobility 2010: A Call to Action for the New Decade*, February 2010.

3. Cambridge Systematics. SHRP 2 Project L03. Analytical Procedures for Determining the Impacts of Reliability Mitigation Strategies. September 2011. http://onlinepubs.trb.org/onlinepubs/shrp2/L35RFP/L03Report.pdf

4. STARS: Sustainable Transportation Analysis & Rating System Pilot Plan Application Manual Version 1.0. January 10, 2012.

Appendix A
Detailed Work Plan

A. DETAILED WORK PLAN

(See Appendix B in Final SMF Study Report)

Appendix B
SMF Place Types

B. SMF PLACE TYPES

(See Appendix C in Final SMF Study Report)

Appendix C
Smart Mobility Performance Measures

C. SMART MOBILITY PERFORMANCE MEASURES

(See Appendix D in Final SMF Study Report)

Appendix D
Complete Streets Assessment

D. COMPLETE STREETS ASSESSMENT

(See Appendix E in Final SMF Study Report)

Appendix E CONSIDERATIONS FOR CSMP GUIDELINE DEVELOPMENT

E. CONSIDERATIONS FOR CSMP GUIDELINE DEVELOPMENT

For the I-680 CSMP, the recommended next steps include:

- Update the CSMP guidance document to incorporate the stakeholder engagement as well as multi-modal system management considerations. This will provide increased transparency on the planning process and project participants will be able to see how their input was incorporated and how it was worked into the smart mobility principles.
- Update the D4 Complete Streets Guidelines to provide better guidance on the level of data collection and analysis appropriate for different types of planning studies. This will help provide a better match between the selected metrics to evaluate smart mobility performance measures and the data that is available.

Steps for Incorporating SMF

For the second generation CSMP, the following modifications to the traditional approach for corridor system management are recommended to update the CSMP guidance document:

1. Incorporate the stakeholder engagement and collaborative partnerships
    - I 680 CSMP was a partnership between D4 Division of Transportation Planning and D4 Division of Operations
    - I 680 CSMP TAC included local jurisdictions, transit agencies and other partners
2. Expand data collection for active modes and transit
    - Incorporate collection of transit, bicycle, and pedestrian inventory data as specified in the D4 Complete Street Guidelines.
    - Include bicycle and pedestrian counts
    - Collect transit ridership data
3. Identify multimodal system management strategies for scenario testing, such as incident management to improve travel time reliability and improvements for bicycle and walk access and bus services to BART stations along the corridor to encourage mode shift from SOV.

Approach

1. Define corridor/study area
    a. System to include parallel arterials as well as transit and bicycle facilities
2. Define Stakeholder Engagement and Outreach Strategy

   a. Assemble Corridor Team
      i. Include all modes
      ii. Staff Working Group
      iii. TAC
      iv. Policy level stakeholders
      v. Public (?)
   b. Define study goals and objectives
   c. Define meeting schedule and agendas
      i. Attendance and outcomes from meetings
3. Develop Preliminary Performance Assessment
   a. Incorporate complete streets assessment
      i. See D4 Complete Streets Guidelines – Define what level of data collection and analysis is appropriate for this corridor study
   b. Expand performance measures to include SMF
      i. E.g. reliability
      ii. Others – Mobility, travel time, delay; safety, productivity;
      iii. Output performance measures – VMT and PMT, VHT and VMT, and PHD
4. Determine Approach, Tools, and Data Needs
   a. Ensure Adequate Corridor Detection
   b. Determine Corridor Analysis Tools and Methods
   c. Develop Data Collection Plan
   d. Finalize Performance Measures
5. Comprehensive Corridor Performance Assessment
   a. Data collection for comprehensive assessment
   b. Utilize tools for corridor performance assessment
6. Identify causality of corridor performance degradation
7. Develop Corridor Analysis Model and Test Improvement Scenarios
8. Develop Corridor System Management Plan