Statewide ITS Architecture Assessment and Support

Process for Updating
Statewide ITS Strategic Development Plan

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Statewide ITS Architecture Assessment and Support

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1. Introduction and Purpose of This Document

The *Statewide ITS Architecture Assessment and Support* project was initiated in 2016 to:

- Assess compliance of the Statewide and Regional Intelligent Transportation Systems (ITS) Architectures with federal requirements and the current state of the practice;
- Assess how these architectures are used in support of transportation planning activities and project development; and
- Identify a set of guidelines for incorporating ITS projects with statewide and regional transportation planning practices.

Because of the extensive work being done by Caltrans in addressing Planning for Operations and Transportation Systems Management and Operations (TSMO), substantial synergy exists between ITS implementation planning and the planning processes that are an output of Caltrans' other efforts. In addition, the U.S. Department of Transportation (USDOT) has recently revised the National ITS Architecture, now known as the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT). ARC-IT has introduced new elements and tools to planning for ITS. Notably, this includes an increased emphasis on Connected and Autonomous Vehicle (CAV) functionality and the availability of:

- A regional architecture development tool (Regional Architecture Development for Intelligent Transportation, or RAD-IT, a rebranding and refinement of Turbo Architecture).
- A project-oriented systems engineering tool (Systems Engineering Tool for Intelligent Transportation, or SET-IT) that can generate project ITS architectures, concepts of operation and system requirements as a subset of a larger regional architecture as developed through RAD-IT.

In light of these exciting and evolving activities, this document will emphasize the relationships between statewide and regional ITS and operations initiatives from a Caltrans perspective, and how they can support the development of a statewide ITS implementation strategy without the need to develop a stand-alone, redundant statewide ITS planning effort.

The recommendations of this document are a key input into the Caltrans *Planning for ITS Guidance* that serves as a companion document to this one. The focus of this document is on Caltrans users, such as Headquarters and District operations staff; meanwhile, the *Planning for ITS Guidance* document is targeted toward a broader audience, including both Caltrans staff and non-Caltrans professionals, such as regional, county, and local stakeholders.

2. Assessing the Feasibility of a Statewide Plan

This section addresses the purpose and need of an ITS strategic implementation plan, and its potential relationship with Statewide and Regional Intelligent Transportation Systems Architectures (SWITSA and RITSA, respectively). The subsections below briefly discuss the current planning and programming landscape in California, the value of a statewide ITS implementation plan, and potential roles and processes for Caltrans to develop and maintain such a plan.

2.1 Introduction

ITS in California has evolved significantly since the early 1990s when these systems were first identified by the Federal Highway Administration (FHWA) as an important tool to reduce congestion and improve safety. In the early 2000s, Caltrans developed the first Transportation Management System (TMS) Master Plan that identified high-level investment needs in four areas: incident management, ramp metering, arterial signal timing, and traveler information. The plan was subsequently updated in 2012 to identify organizational changes and process improvements to go along with asset investments. Since then, there has been a flurry of activities and policies at the state level, including, but not limited to:

- Organizing for Corridor Management / Connected Corridors Program
- Caltrans State Highway System Management Plan
- Connected Corridors Pilot Projects
- Connected and Autonomous Vehicle (CAV) Pilot, Demonstration and Deployment Activities
- System Planning to Programming Study
- Planning for Operations Strategic Work Plan
- Transportation Systems Management and Operations (TSMO) Program Plan
- Complete Transportation Framework (refined planning and project development process)
- Passage of Senate Bill 1 (SB 1) – Road Recovery and Accountability Act and draft California Transportation Commission (CTC) Guidelines for SB 1 funding programs
- Transportation Asset Management Plan and new State Highway Operation and Protection Program (SHOPP) Project Nomination Process
- Assembly Bill 1447, Traffic Signal Synchronization Improvements Eligibility for Cap and Trade Funding

These studies and activities will not all be summarized in this document. However, it is clear that Caltrans has demonstrated its commitment to ITS operational investments, its goal to better integrate performance-based operations into their planning and programming processes, and its opportunity to fund many strategic ITS projects statewide in light of new available funding.

A similar focus is occurring at the District and regional levels. In Districts 3 and 10, Regional Concepts of Transportation Operations (ITS/Operations Strategic Plans) and ITS/Operational Improvement Plans (Investment Plans) have been developed. In San Diego (District 11), the first Integrated Corridor Management (ICM) project was implemented along Interstate 15, and a second implementation is planned for Interstate 805. Similar implementation under the Department's "Connected Corridors" brand is underway on Interstate 80 in the Bay Area (District 4). Finally, District 7 is working with the Los Angeles County Metropolitan Transportation Authority (LA Metro) on I-210 and I-110 Connected Corridor implementations, and the Department is pursuing additional Connected Corridor deployments and ITS investments statewide.

ITS projects in California may be funded through a number of mechanisms, including the State Highway Operation and Protection Program (SHOPP), SB 1 Congested Corridors Account, regional and county agencies, federal funding, or any combination of these. Two of the most recent developments merit particular discussion and are presented below.

2.2 Senate Bill 1 and CTC Guidelines

SB 1 significantly increases transportation funding in California. The bill estimates an additional $50 billion over the first 10 years alone. The bill directs most of the funding towards preservation projects on the State's roadway system and bridges. However, it does offer funding for other types of investments. For example, it allocates $250 million annually to Congested Corridors. ITS projects are eligible, especially if they are related to a corridor study and if the study is undertaken in collaboration with regional partners. Further, ITS is identified as one of the four asset classes in the statewide Transportation Asset Management Plan.

SB 1 requires the CTC to develop guidelines for the State and its partners on all SB1 funding programs. The Interim SHOPP Guidelines were adopted on June 16, 2017. In it, the Commission specifically permits Transportation Management Systems (TMS) and Traffic Management Centers (TMC) improvements to be eligible for SHOPP funds along with multi-modal corridor projects[1]. The Solutions for Congested Corridors Program (SCCP) guidelines were subsequently adopted on December 6, 2017.

2.3 Interim Guidance on Pre-PID Project Nomination Process

In April 2017, Caltrans issued a memorandum that defines the pre-PID (Project Initiation Document) Project Nomination Process. It outlines the identification of "anchor" projects and the evaluation of "satellite" projects funded simultaneously with anchor projects (subject to approval processes). This project nomination process is consistent with the SHOPP guidelines defined by the CTC and

[1] Interim State Highway Operation and Protection Program (SHOPP) Guidelines, California Transportation Commission, June 16, 2017, Section 25 (Eligibility), p. 8.

hypothetically allows ITS projects to be either anchor or satellite projects funded in conjunction with major preservation projects.

2.4 The Need for High-Priority ITS Projects

2.4.1 Project Development Opportunities

In short, there are new opportunities for funding ITS projects thanks to SB 1, including the SHOPP and the SCCP. The project nomination process also allows ITS projects to be anchor projects. But a key question is: how can these projects be identified and then supported throughout their development process?

Hypothetically, a statewide ITS Implementation Plan detailing high priority ITS projects can address this question. Such a plan would typically include statewide goals and objectives, along with a list of projects with performance assessments that map to the goals and objectives, and preliminary costing for each project. However, there are challenges to accomplishing this effectively at the statewide level.

First, regions in California can have different priorities. Second, and more importantly, it is the Caltrans Districts that are the entities responsible for operating the State Highway System (SHS). As such, the Districts are in the best position to assess their needs and identify promising projects. Finally, as language in SB 1 clearly emphasizes, collaboration with partner agencies is critical. The Regional ITS Architecture process, as discussed earlier in this project, is a tool that both requires and encourages collaboration between agencies when done correctly.

2.4.2 Relationship of ITS Architectures and Project Definitions

There is an urgent need for developing a list of high-priority ITS projects where a strategic ITS or Operations planning process is not yet underway. Findings of the Caltrans Planning for Operations Strategic Work Plan conclude that Districts should develop lists of high-priority ITS projects as a basis for coordinating with partners and project nominations. In the short term, such lists could be compiled from previous studies and from guidance from functional experts. Then, the proposed projects can be assessed using sketch planning tools such as the California Benefit Cost (Cal-B/C) model. In the longer term, the high-priority ITS project list should be updated using more detailed corridor plans, preferably conducted in collaboration with partner agencies, similar to the strategic and investment plan development activities as performed in Districts 3 and 10.

Additionally, a process is needed to ensure that: (a) proposed projects are consistent with the regional ITS vision (involving Caltrans and regional stakeholders) as reflected in their RITSAs, and that conversely, (b) the architectures reflect the proposed projects that are needed by the Districts or that include them as key partners.

Figure 1 provides a view that addresses District-focused development activities. This view addresses the relationship of projects to regional architectures as well as to a statewide ITS prioritization effort documented through the SHOPP. In turn, the SHOPP ITS projects may be related to the Statewide ITS Architecture (SWITSA) that provides a statewide framework for pertinent standards relevant to all regions, interfaces between regions, and programs/projects that may occur in parts of the state that are outside the realm of an MPO.

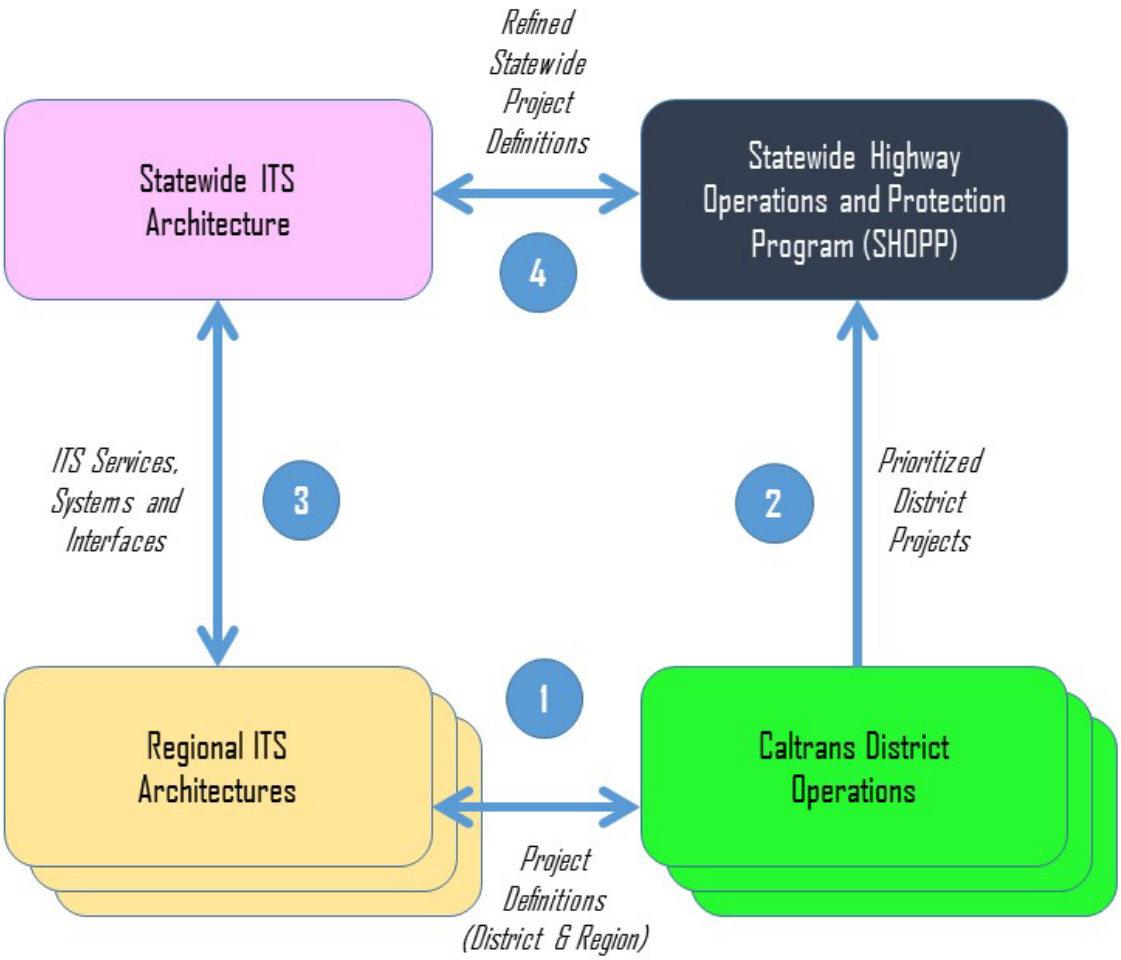

Figure 1. Project Development and ITS Architecture Coordination

The most significant priority in developing a statewide list of ITS projects (using SHOPP as the vehicle) is that the Caltrans Districts first need to play a key role in their corresponding regional architectures, Step 1 in the figure above. The "two-way" arrow reflects that projects may either be defined and developed prior to RITSA updates and thus would help in informing the RITSA, or the RITSA may create or refine the framework in which projects (whether Caltrans District initiatives or others where Caltrans is a partner) are defined and developed.

The processes associated with Step 1 would include developing project definitions, as illustrated in Figure 2. Doing this requires that Caltrans Districts collaborate with regions on defining operational objectives, identifying operational and performance needs, establishing the needed ITS strategies and services needed, and assuring that District programs and projects are incorporated into regional transportation plans and Regional ITS Architectures. Further, the deployment strategies should be detailed in order to define projects that:

- Are system wide in nature;
- Focus on specific corridors (e.g., "Connected Corridors"); and
- Provide targeted improvements incorporated under life-cycle-based upgrades to existing devices, or may be new components, communications or other elements incorporated within other larger, projects such as road reconstruction, widening, or Express Lane deployments.

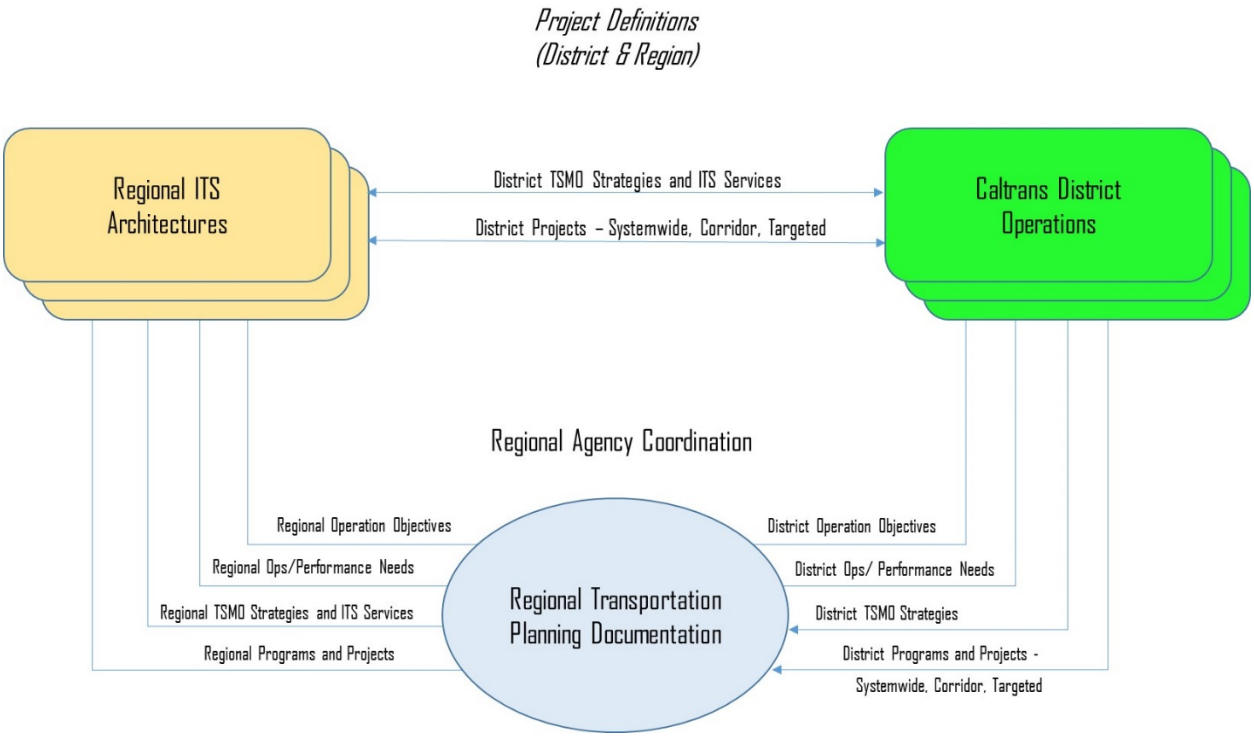

Figure 2. Step 1 - Caltrans District Project Definitions in Coordination with Regional ITS Architecture Activities

Step 2 involves the application of specific statewide selection criteria defined and agreed to by Caltrans Headquarters and the Districts. This creates a list of prioritized District ITS projects based on the planned programs and projects developed as part of regional collaboration efforts as described above. Those projects meeting the SHOPP criteria then should be prioritized through the SHOPP development process and incorporated into a statewide ITS project prioritization under the umbrella of SHOPP as shown in Figure 3. Other projects that may be significant from a regional, multi-agency context may be eligible for other funding (e.g., Federal or other SB1 program) opportunities.

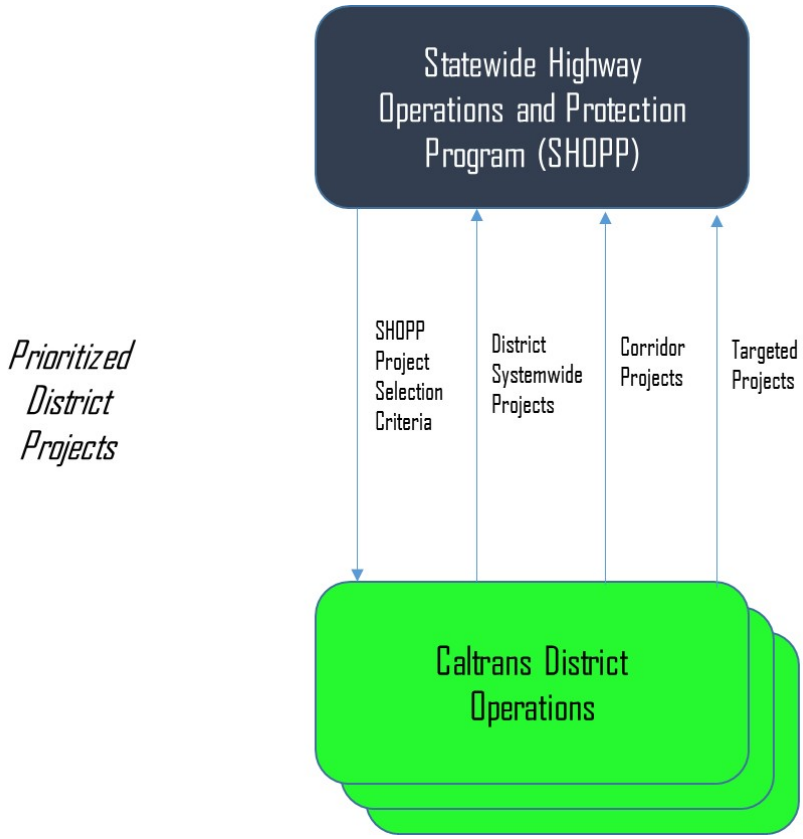

Figure 3. Step 2 – Incorporation of Prioritized District Projects into SHOPP Plan Based on Project Selection Criteria

Once districts have adopted their list of high-priority ITS projects for SHOPP, taking into consideration project types, Caltrans can aggregate these on a statewide basis to create the statewide list that is incorporated into the "Ten-Year SHOPP Plan." To do this, the Ten-Year SHOPP Plan should evolve to dedicate a more substantial portion to operational improvement and ITS investments in a manner similar to pavement and bridge chapters. Categorization of system wide, corridor or targeted activities should address particular types of programs on their own merits (e.g., a system wide traveler information project and a series of critical life-cycle detection upgrades may both be necessary, and categorization of these projects would assure they are not necessarily traded off against one another).

Step 3 (mapping of regional architectures into a SWITSA) and Step 4 (tying prioritized statewide projects into the SWITSA) assures that standardization and coordination between regions is established and that particular interregional interfaces and statewide standards (e.g., V2I and V2V) are reflected in the regional architectures across the state in a consistent fashion. However, the main priority remains the coordination of district projects with regional architectures, as that would be expected to serve as the primary basis of ITS project activities reflected within statewide plans.

In Figure 4, Step 3 (relationship of regional and statewide ITS architectures) is further detailed. It addresses how review of all regional architectures in a statewide context can assist in:

- Defining gaps in services or other functions related to corridors not included within regional architectures;
- Defining interfaces and information-sharing needs between regions; and
- Establishing standards for consistent wireless communications, payment, and other functions across all regions.

The latter will be critical in the future with the advent of connected V2X communications, electrification and charging activities, and it builds on current statewide standardization activities related to electronic tolling and future road-pricing activities.

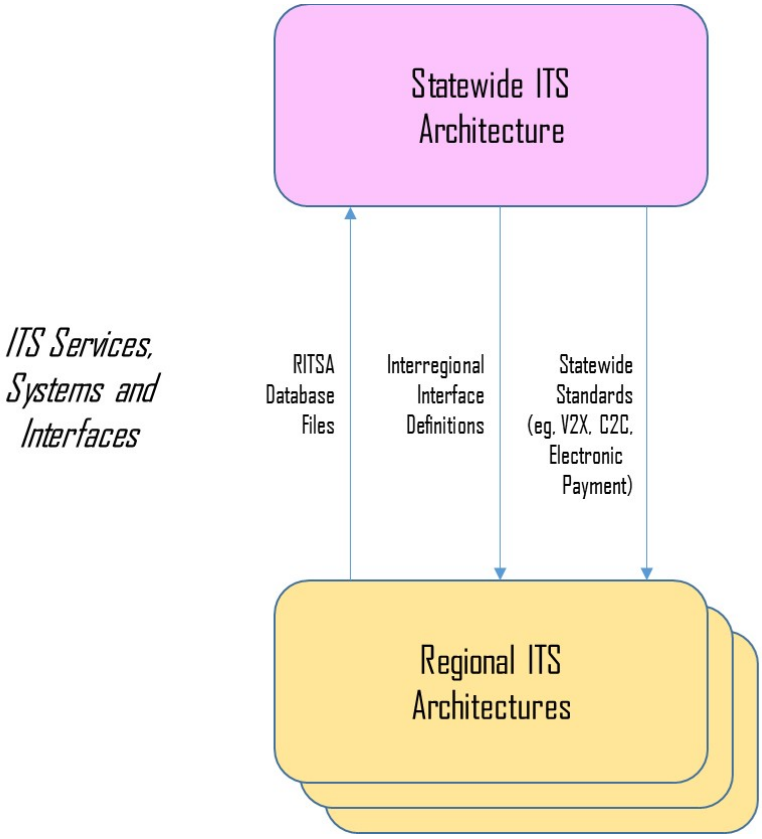

Figure 4. Step 3 – Relationship between Regional and Statewide ITS Architectures

In Figure 5, Step 4 (coordination between SHOPP and Statewide ITS Architecture development) is further detailed to describe how Statewide ITS Architecture definitions and gap assessments may be used to further define statewide initiatives to be included in the Ten-Year SHOPP Plan. This relationship involves coordination with the CTP and other initiatives to identify services and projects that provide interregional connectivity as well as ITS functions on the State Highway System not

addressed by RITSAs. Statewide performance measurement, toll system design, V2V and V2X standards across the state, and statewide road weather information sensors are examples of "gaps" that should be addressed.

Step 4 also includes high-level objectives and direction provided through the CTP and SB 1. These drive particular standardization and coordination activities at the regional or district level, in particular, project prioritization for District ITS projects and standardization of interfaces and coordination with individual Regions across the state. The SB1 guidance for SHOPP in particular addresses transportation management systems and connected corridor funding programs.

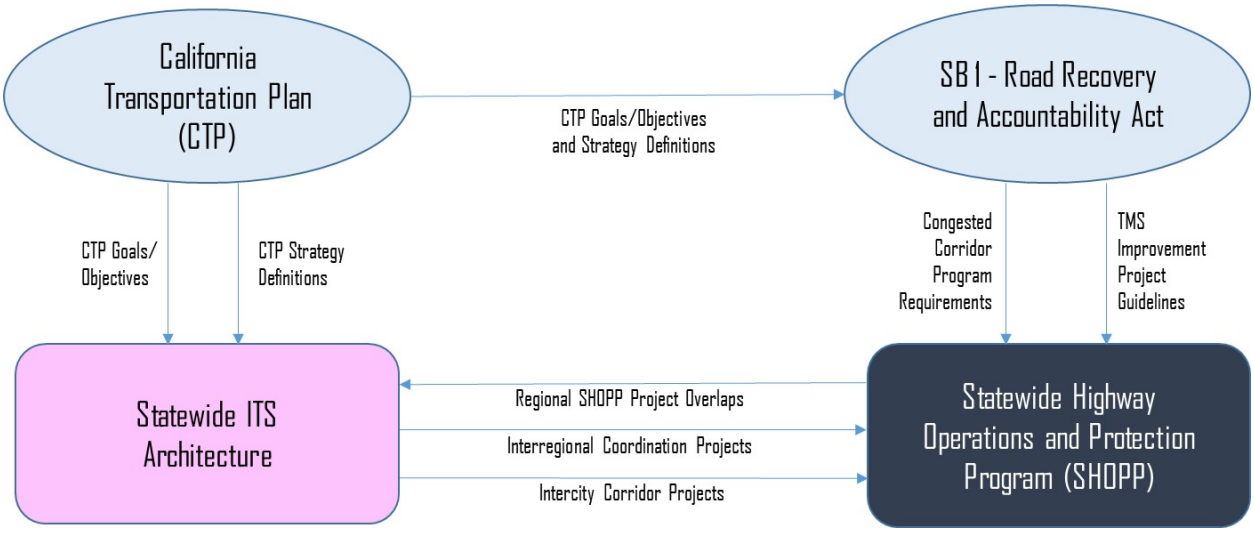

Figure 5 Step 4 – Statewide ITS Architecture and SHOPP Coordination Driven by CTP and SB1 Guidance

2.5 The Role of Headquarters

Using the approach of aggregating District ITS project lists in lieu of developing a stand-alone statewide ITS implementation plan, Caltrans Headquarters can still have a statewide list of priorities, along with expected performance improvements. Headquarters can then advocate for these critical investments and, if funded, monitor the performance improvements achieved. Moreover, Headquarters can also help provide funding for the Districts to conduct corridor studies in collaboration with the regional and local partners. This role differentiation between Headquarters and Districts is consistent with both current and emerging practices, such as the Transportation Asset Management Plan and the Complete Transportation Framework.

All of the planning for operations activities underway or recently completed at the Headquarters level are providing the overall direction consistent with the above activities. Such a direction minimizes the need for a separate stand-alone statewide ITS Strategic Implementation Plan (SIP). This focuses ITS program and project development activities on the District level. However, the Districts need guidance and support from headquarters in providing District-focused, multi-year ITS

Plans that can then be incorporated into a statewide program and SHOPP, as well as into regional transportation plans. Such direction and guidance should involve specific guidelines for incorporation of projects into the Ten-Year SHOPP Plan along with other statewide programs, as well as related guidelines for identifying and incorporating regional ITS projects of statewide relevance. This has the effect of assuring consistency between statewide and regional efforts, also assuring both statewide and regional support for specific projects that benefit both the SHS and regional stakeholders.

2.6 ITS Planning Activities

Successfully managing and operating the regional transportation system depends upon deliberate, sustained collaboration among operators, planners, and other key stakeholders to establish direction and decide how to move forward. Meaningful and realistic objectives and the strategies for achieving them, including institutional relationships and performance expectations, are necessary to guide the effort.

These efforts may be formalized through several different means, but should be reflected within the regional transportation planning process. These include:

- Regional Concept for Transportation Operations, or RCTO (focus on particular operational business areas, corridors, or agency operations activities)
- Regional or Agency ITS Strategic Plans (addressing ITS needs for all modes and/or facilities within a region, or that are operated by an agency, e.g., Caltrans District)
- Regional Transportation Planning process, incorporating input from RCTOs, ITS Strategic Plans, and other inputs to identify projects and programs incorporated into regional, multi-year Transportation Improvement Plans

An RCTO provides a framework that guides collaborative efforts to improve system performance through management and operations strategies. The RCTO concept was the result of a broad-based Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) working group that addressed linking planning and operations. The RCTO brings together systems engineering concepts and the experience of successful transportation planning and operations partnerships. RCTOs can be organized by sub-region or freeway corridor with strategic initiatives formulated by functional areas. For example, RCTOs have been developed in other states and regions that include focus areas such as Incident Management, while others may focus on tolled Express Lane networks.

The term '*Regional* Concept for Transportation Operations', as defined by FHWA, does not necessarily infer only being established as a Metropolitan Planning Organization (MPO) initiative. A similar management tool to assist in planning and implementing Transportation System Management and Operations (TSMO) in a collaborative and sustained manner can begin with a Caltrans District-focused ITS/Operations Strategic Plan. Figure 6 illustrates this relationship.

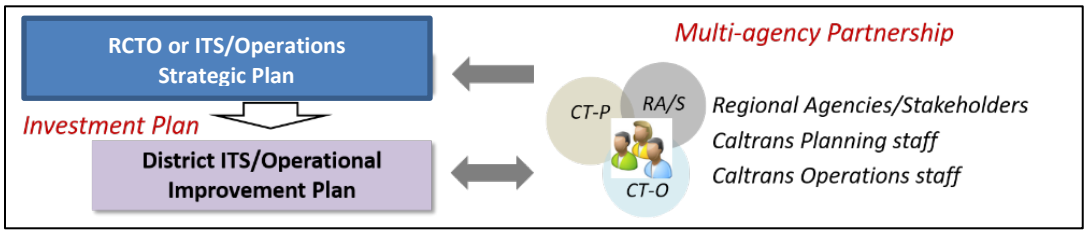

Figure 6. Relationship of Operations and Planning Activities at the Regional Level

Regardless of the methodology used, a collaborative planning effort for definition of ITS programs is required to achieve common objectives. Successfully managing and operating the regional transportation system, including state highways, requires deliberate, sustained collaboration among operators, planners, external partners, and other stakeholders, more so now than ever before. Shared and realistic objectives guide this effort, to agree on the best course(s) of actions to follow. This collaboration prevents unnecessary duplication, limited or slowed progress, inconsistent traveler information, and underutilized or incompatible technologies. Caltrans has developed a Strategic Management Plan 2015-2020 (SMP) to document its agency's mission, goals, objectives, and performance measures. The RCTO, ITS plan, or regional plan should support the SMP-identified goals, objectives, and performance targets and make a linkage between regional and statewide goals.

These also provide the opportunity to link planning and operations. Just as depicted in Figure 7 below for regional decision making, connecting operations activities to the transportation planning process offers benefits for District planners interested in advancing cost-effective strategies to improve system performance and offers benefits to District operations staff who are seeking support for regional operations strategies. Note also that similar opportunities arise through connection with the Regional ITS Architecture.

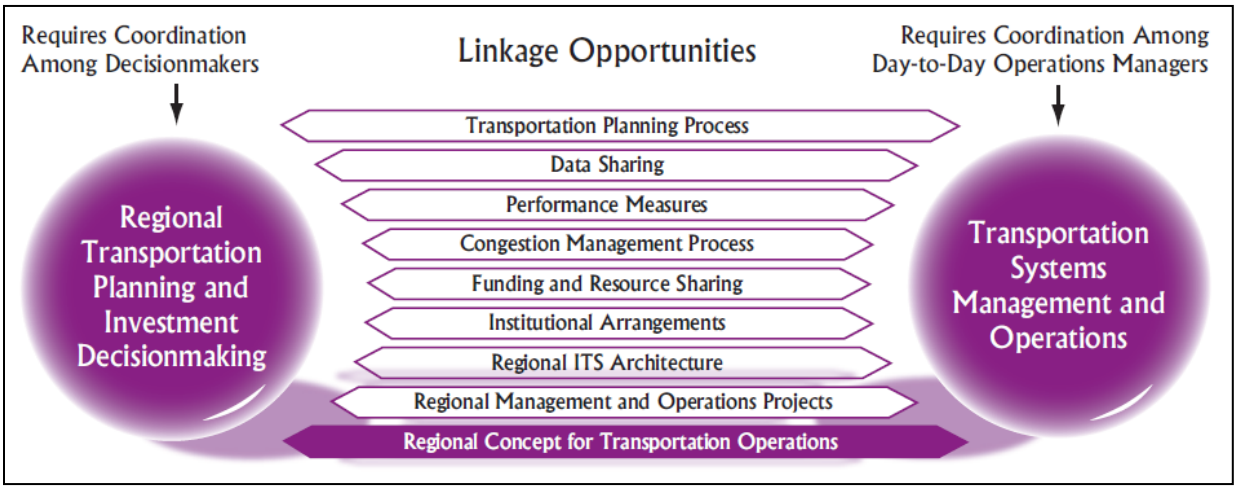

Figure 7. From Regional Concept for Transportation Operations: The Blueprint for Action – A Primer, FHWA, 2007

2.7 District ITS/Operational Improvement Plan

The process of planning for future operations is evolving. An ITS/Operational Improvement Plan can facilitate implementation of ITS and operational improvement projects along SHS corridors within a Regional Transportation Plan (RTP), and that are part of the corresponding RITSA as per Section 2.4.2. The Plan can provide an investment strategy, in collaboration with Caltrans' local and regional partners, to identify and prioritize ITS and operational improvements throughout the District, in support of the region's current and future TSMO activities. The Plan presents the proposed value investments of cost-effective projects and strategies that provide a high benefit-cost ratio and/or yield desired performance outcomes.

Once the projects and other actions are valued, they can then be included into the updates of the ITS/Operational Improvement Plan for prioritization in coordination with partner agencies. The Plan can be utilized to optimize the SHS within the District, by using ITS and other operational strategies that can be deployed quickly and are known to yield better return on investment with high benefit to cost. It could help partner agencies think through and reach consensus on what they want to achieve in the near term (0-3 years), over the medium term (3-5 years), and in the long term (5 years and beyond). Furthermore, the Plan informs an ITS implementation strategy for those projects.

This Plan can serve as a tool for Caltrans, regional planners, operators, and decision-makers to prioritize the best projects for limited funding, to utilize today's technology and be able to integrate with future technology. In this manner, this plan would maximize the effectiveness of using available funds for projects that help achieve performance goals.

In the past, for most Districts, ITS and operational improvement projects had been funded by the relatively modest SHOPP Mobility Account. Because of limited funding, it has been difficult for staff to develop and implement these projects. The recently implemented Caltrans Transportation Asset Management initiative, which focuses more on "fix-it first" investments, could impact how the ITS and operational improvement projects will be programmed in the SHOPP. With the passage of SB1 and the anticipated increase in dedicated SHOPP funding, opportunity to increase ITS and operational improvement investments is expected.

In addition, some Districts may also be able to coordinate and match funds for ITS and operational improvement investments from local agencies if such agencies can clearly share in the benefits.

2.8 ITS Planning Relationship to RITSA

RITSAs serve as the basis for ITS strategic plans or RCTOs by identifying services, functional requirements, and project concepts that support regional transportation goals and objectives. The RITSA can be characterized as broadly defining what transportation operations agencies in the region are doing with technology and what they would like to do, and who would be engaged in

providing and benefitting from the related services. In contrast, ITS planning efforts as described in the previous sections define in specific terms what is committed to be achieved operationally over the long-term, how the partners are going to work together, and how their collaborative effort is going to be shaped. It provides many of the institutional underpinnings that in turn benefit RITSA development.

Developing an RCTO or Strategic Plan that generates programs or projects incorporated into the SHOPP or regional transportation plans allows the Divisions of Planning and Operations and its partners to "drill down" on one or more ITS services identified during the development of the ITS architecture.

In short, the primary purpose of developing a RITSA is to illustrate and document regional integration so that planning and deployment can take place in an organized and coordinated fashion. The purpose of an RCTO is to provide a group of collaborating planners and operators a common operations objective and a collaborative strategy to achieve that operations objective. The ITS architecture establishes common parameters for ITS, but it does not include an implementation strategy that is part of an RCTO.

Because many TSMO strategies are underpinned by ITS, the coordination of planning for ITS among agencies at the institutional and technical level is an essential element to planning for operations. The RITSA, with a focus on integrating transportation services supported by ITS, presents a significant opportunity to support the needs for effective planning for operations. The RITSA helps answer the following important questions:

- What TSMO strategies supported by ITS may be available to help achieve our operations objectives?
- What data is available in the region to monitor transportation system performance and track progress toward operations objectives?
- What are the gaps in providing transportation system management and operations across our region?
- How can we most effectively integrate a new TSMO strategy supported by ITS with other existing or planned technology deployments to provide a greater level of service for the customer?
- How can we define this TSMO project or program in terms of functional requirements, operations concepts, supporting ITS standards, etc.?

3. Statewide Role – Furthering the ITS Architecture, TSMO, and RCTO Relationship

This report has addressed the importance of deriving a statewide ITS development strategy from projects developed by the Caltrans districts and leveraged through RITSAs. The statewide role,

relative to the relationship between regional architecture, TSMO, and RCTO plans, can be to provide the overall framework for activities and components that need to be standardized statewide (e.g., Center-to-Center communications), or that need to be compatible with national requirements. The SWITSA is an ideal platform for this. Furthermore, such a framework is critical to vehicle-focused applications such as electric vehicle charging, vehicle–to-infrastructure and vehicle-to-vehicle communications.

Although MPOs retain the lead responsibility for regional transportation planning, the planning functions in each Caltrans District and on a statewide basis are critical to defining programs and projects that are of the highest priority to the Department. Caltrans has embarked on a high-level focus toward TSMO activities. At the District level, development of ITS/Operations Strategic Plans and/or RCTOs is becoming more common. While a RITSA by definition is consistent with regional planning goals and objectives, the architecture components that involve Caltrans should also correspond with Statewide and District operational goals and objectives. This includes focusing on statewide goals and objectives relative to intercity and cross-cutting ITS activities that are of statewide relevance.

Likewise, identified statewide ITS project needs nominated to the SHOPP or other funding programs should be incorporated into architecture developments. At the same time, other SHOPP-eligible ITS projects may be defined and developed as a result of architecture development, driven in part by standards and coordination activities that may be needed to further Caltrans' mission.

Caltrans Headquarters and the Districts will each have key roles to play in providing not only support to MPOs and other entities that are leading architecture development activities, but themselves providing leadership in promoting and supporting architecture development in TSMO activities (including ITS/Operations Strategic and Investment Plans) or in helping Caltrans improve its outreach and relationships with other agencies.

Understanding and building on Caltrans' institutional capabilities regarding TSMO is also important. At a headquarters or District program level, one way that progress in achieving TSMO goals and objectives (including identifying, deploying and operating ITS) can be assessed is through the Capability Maturity Model (CMM) process. Caltrans uses this process to identify and address the TSMO capability issues.

Figure 8 provides an overview of the current and future states involving TSMO activities as related to business processes, systems and technology, performance measurement, culture and organization.

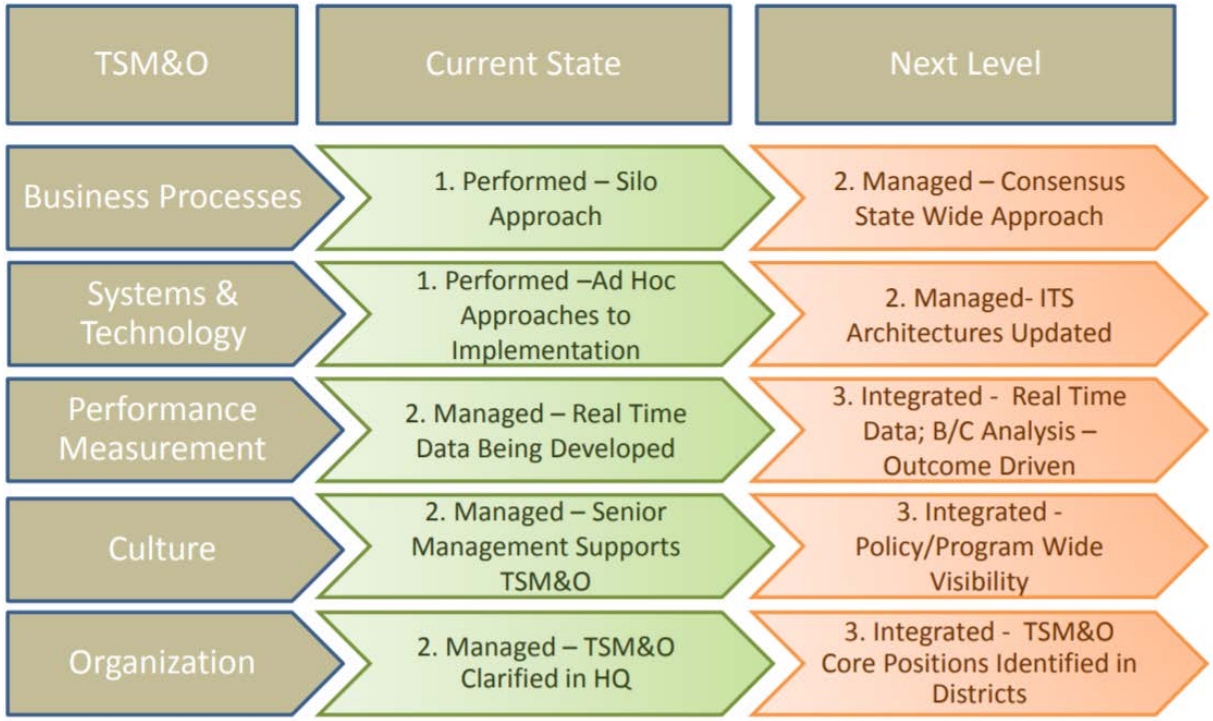

Figure 8. TSMO Process States (2013 "Current" State and Future)
(Caltrans Regional Operations Forum, July 2016, "TSMO Caltrans Statewide Perspective", Nick Compin)

As is indicated in the CMM assessment presented above, one of the core tenets of moving into a TSMO environment is moving from ad hoc program and project implementation approaches to a managed approach involving updated ITS Architectures as well as systems engineering. Based on the AASHTO TSMO "One-Minute Guidance" as previously presented as part of the Caltrans Regional Operations Forum in July 2016, the two levels that follow from the "systems and technology" perspective would include:

- Systems and technology standardized, documented and trained statewide, and new technology incorporated
- Systems and technology routinely upgraded and utilized to improve efficiency performance

This indicates both the importance of developing and updating RITSAs, but also the importance of statewide coordination (including SWITSA) as the next level of priority, and a consistent process of updating and refining RITSAs as well as SWITSA to reflect evolving activities, applications, and technologies.