



# **Statewide ITS Architecture Assessment and Support**

Caltrans Planning for ITS Guide: 2018 Edition



January 2018

## Statewide ITS Architecture Assessment and Support



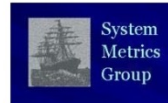
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## Preface

The first “Planning for ITS” guidebook was published by Caltrans in 2007 as part of its Statewide Intelligent Transportation Systems (ITS) Architecture and System Plan initiative. It was subtitled “A Guide to Incorporating Technology into Transportation Planning and Programming.” Since that document was released, ITS has evolved into a substantially broader and more complex spectrum of services and applications, involving not only public sector programs, but substantial private sector initiatives, many led by California companies.

For example, smartphone applications including real-time mapping, location-tracking, and crowd-sourced information, have revolutionized traveler information services, and have helped enable shared mobility services. Electronic and dynamic road pricing using express lane and cashless toll facilities has become far more common. Finally, the advent of connected and autonomous vehicles (CAVs), large-scale vehicle electrification, and their confluence with shared mobility and other personal travel, along with goods movements, will have a distinct impact on transportation operations and travel demand.

Related to all this is the large-scale increase in the quantity of data that may be captured from vehicles and travelers alike. Access to such data will enhance public agencies’ abilities to monitor and manage system performance to address congestion and reduce crashes.

The California Transportation Plan 2040 (CTP) published in 2016 clearly acknowledges the changing transportation landscape. The CTP envisions an improved multi-modal transportation system enhancing mobility, safety and security, and supporting a vibrant economy, social equity, and environmental stewardship. The Plan explicitly proposes implementation of elements that entail the use of advanced technologies and telecommunications, including both traditional ITS as well as connected and automated vehicle applications.

In light of this CTP vision, **it is thus not only advisable, but imperative that ITS is incorporated into every facet of transportation planning and system operations.**

Additionally, the Caltrans 2015-2020 Strategic Management Plan (SMP) identifies specific goals, objectives and desired outcomes (performance measures). For example, system performance objectives include improving travel time reliability and reducing travel times for all modes, as well as integration and operation of the transportation systems with a particular focus on multi-modal system information. Such objectives are frequently addressed using ITS.

Regions across the U.S. generally utilize the National ITS Architecture as a basis for developing an overall framework for coordination and ITS deployment. Many have done so with notable success. However, not all regions and agencies have effectively used either ITS architectures or systems



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engineering tools as part of a transportation planning process tying transportation goals and objectives to actual project outcomes. As a result, many operations-oriented transportation projects require more time and cost to plan, deploy, and implement.

Thus, a salient advantage of developing, utilizing and updating ITS architectures is the opportunity to jointly engage planning, operations, and technology specialists in developing the regional program and targeting specific projects for deployment. While each specialist may provide a different perspective of the transportation network, they share a common interest as professionals in improving mobility and safety and reducing the impact of transportation services on the environment.

This updated “Planning for ITS Guide” is intended to prepare California for the future, by addressing a process that encompasses planning, programming and initiation of projects that utilize advanced technology and prepare for future activities. Experts who are engaged in all the steps of the planning and programming process have provided review. Updates of this Guide will continue to occur periodically, as our business procedures, policies and conditions evolve and change.

*California Department of Transportation  
Division of Transportation Planning  
January 2018*

## Purpose and Use of This Guide

Planning for advanced transportation technologies, or ITS, incorporates a set of tasks to **successfully integrate or link information systems** and the devices that provide data and information. In this process, there are three objectives:

- 1) Identify the needs of end-users – the traveler, public servant, first responder, service provider, and merchant – and translate those needs into technological solutions. This is the core idea behind creating a **framework or “architecture”** that describes transportation services in the form of diagrams, tables and text.
- 2) Identify planning-level transportation goals and objectives at the state, regional and/or local level, and identify the outcomes needed, specifying the strategies, programs and projects that will provide measurable benefits and improvements that map to those goals and objectives.
- 3) Relate the specific strategies, programs and projects to the ITS architecture, in particular the services described in the architecture, for the purposes of establishing common standards, interfaces and protocols by which the higher-level program and project definitions can evolve to project-level designs. This documentation feeds directly into the **systems engineering assessment** process.



*The U.S. Department of Transportation states that “ITS improves transportation safety and mobility and enhances American productivity through the integration of advanced communications technologies into the transportation infrastructure and vehicles. Intelligent Transportation Systems (ITS) encompass a broad range of wireless and wire line communications-based information and electronics technologies.”<sup>1</sup>*

This Guide provides the reader (whether from Caltrans or another planning or operations entity) with an overview of how ITS can be reflected in transportation planning goals and objectives, particularly those involving Transportation System Management and Operations (TSMO). It will identify best practices and recommend particular standardization of terminology in development of ITS architectures that can be used as a roadmap for deployment of the planned ITS programs and projects and serve as a linkage to deployment activities. It will include a reference on how the 2017 update of the National ITS Architecture, entitled the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT), can be used to support these activities. It should be noted that ARC-IT not only addresses the formulation of regional architectures but also how the Systems Engineering (SE) process applies to projects that will delivery specific services within the Architecture.

<sup>1</sup> <https://its.dot.gov/about/faqs.htm>, “What is ITS” FAQ, January 18, 2018



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The Guide follows the Planning for Operations paradigm. The focus is on development of regional / District ITS initiatives within the framework of Regional ITS Architectures and planning. Statewide ITS activities should build upon regional and District ITS activities, with the Statewide ITS Architecture focused on interregional interfaces, data sharing, intercity corridors not contained completely within a region, as well as statewide data sharing, management and other activities. Additionally, standards related to CAVs and V2V and V2I protocols require consistency throughout the state (or with other states), and should be considered as part of a future Statewide ITS Architecture update.

The organization of this Planning for ITS Guide is as follows:

- **Policy and Strategic-Level Planning**, including high-level goals and objectives, TSMO, interagency activities, and assessment of District, regional and statewide planning.
- **ITS Planning and Architecture Development**, addressing the development of regional ITS plans and RCTOs, development of ITS architectures using ARC-IT, and regional and statewide implementation planning (including SHOPP), and statewide ITS architecture development.
- **Programming**, looking at Federal (FAST Act), state, regional and private partnering opportunities for developing, funding and implementing ITS projects.
- **Project Engineering and Development**, focusing on Systems Engineering and the use of the SET-IT tool as part of ARC-IT.



**Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)** serves as the national ITS architecture reference and describes the framework of an integrated ITS project development process. It provides tools for both regional ITS architecture development and systems engineering documentation for projects that are subsets of the architecture.

**Statewide ITS Architecture** provides a framework for state-level standards used across all regions as well as interfaces between regions, along with intercity corridors not addressed under current regional architectures. The intention is for the Statewide Architecture and related planning activities to leverage the regional ITS architectures covering much of the state.

**Regional ITS Architecture** is the framework for integrated ITS project development in a region as specified by its stakeholders, including definition of agency roles, ITS services, interagency coordination and interfaces, and definition of components operated by agencies that are incorporated into regional TSMO activities.



### 1. Policy and Strategic Level Planning

This section presents the role of ITS and operations activities in supporting statewide High-Level Planning Goals and Objectives, and how ITS and operations activities fit in. It provides an introduction to Planning for Operations, the relationship of ITS to TSMO activities, and addresses the Capability Maturity Model that has been developed to identify statewide program direction and steps leading to “continuous improvement”.

The intent of this section is to provide the reader with the context by which incorporation of ITS and technology into transportation planning activities is essential in furthering improvements to mobility and safety within the state. The Chapters that follow provide more detail on the actual processes that tie planning, ITS architecture and deployment activities together at the regional and statewide levels.

#### 1.1 Caltrans’ High-Level Planning Goals and Objectives

At their highest level, California’s transportation policies contain goals that explicitly support improved transportation operations and the intelligent systems used by Caltrans and partner agencies to optimize the efficiency of the multi-modal surface transportation system.

##### 1.1.1 CTP 2040

The California Transportation Plan 2040 (CTP 2040) document, a statewide transportation plan developed by Caltrans, states that, “California is dedicated to maintaining and efficiently operating our existing highway system...” As part of that dedication, the Plan continues, “Fix-it first goes beyond maintaining bridges and pavement; it also means the system has good operations management, such as ramp metering lights, mode separation, congestion pricing, and other intelligent transportation systems (ITS) technologies that can greatly increase existing highway capacity without adding lanes to

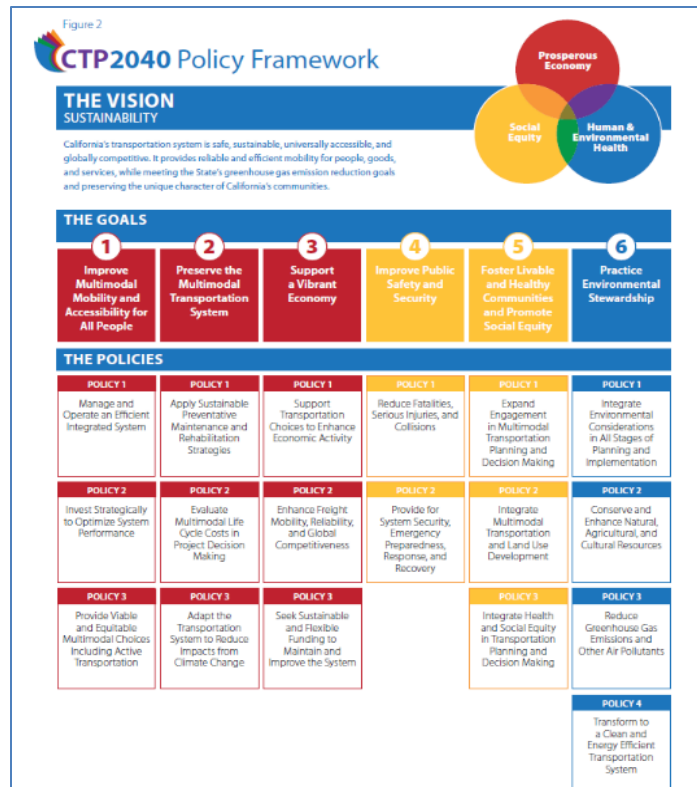


Figure 1. CTP 2040 Policy Framework contains goals and policies that specifically indicate the need for ITS and technology solutions.



California's state highway system (SHS)<sup>2</sup> CTP 2040 also expects ITS and Transportation Management Systems (TMS) to contribute to Greenhouse Gas (GHG) emission reductions. As illustrated in Figure 1, the CTP specifically defines goals that ITS and technology are well-suited to, offering a number of strategic policies that focus on system operation as opposed to traditional expansion of capacity.

Goal 1 supporting the overall Vision of CTP 2040 is, "Improve Multimodal Mobility and Accessibility for All People." At a very high level, ITS-related policies and recommendations supporting Goal 1 include the following examples:

- Improved multi-modal corridor system management to maximize system efficiency using ICM (e.g., ITS, HOV lanes, dynamic HOT lanes, BRT lanes, rail lines, smart parking, vehicle-to-vehicle (V2V) and infrastructure-to-vehicle (V2I) communication, shared ride and vehicle services, Complete Streets).
- Invest strategically to optimize system performance.
- Provide real-time multi-modal system information to the public on all major commute corridors.
- Make data available statewide.

Goal 2 supporting the overall Vision of CTP 2040 is "Preserve the Multimodal Transportation System." An ITS-related policy and recommendation supporting Goal 2 may include implementation of an asset management framework for improving on-going system maintenance. Such a combination of asset management systems and ITS have some overlapping functionality, and they can also provide underlying data for system performance monitoring.

Goal 3 supporting the overall Vision of CTP 2040 is, "Support a Vibrant Economy." At a very high level, the Department can promote, in conjunction with university and private sector partners, various research, development, demonstration and deployment efforts that use cost-effective technologies and operational strategies to support enhancements in personal mobility, reduce congestion, improve safety, and expedite goods movements. Additionally, implementation of a road pricing strategy may support multimodal transportation improvements while recognizing social equity issues.

Goal 4 supporting the overall Vision of CTP 2040 is, "Improve Public Safety and Security." The CTP 2040 document states that, the California Strategic Highway Safety Plan (SHSP) is the "back bone" for the CTP 2040's safety goal, with the main objective being achievement of a significant reduction in fatalities and serious injuries on all public roads. To that end, the SHSP provides a strategy to apply advanced technology to enhance work zone safety, through review of best practices, and creation of guidance for use of queue warning systems and other promising work zone ITS systems. The SHSP also promotes the use of technology for improving commercial vehicle safety.

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<sup>2</sup> California Transportation Plan 2040 (CTP 2040); Caltrans; June 2016

The CTP 2040 document concludes by reiterating the necessity of coordinated efforts at all levels of governments to achieve the transportation goals set out in CTP 2040. Further, the necessity of the coordinated efforts indicates the importance of a unified approach to statewide transportation planning and policy.



**CTP 2040 envisions the use of advanced technologies and telecommunications to fulfill its vision.** These include “using management systems and technologies to maximize system efficiency through integrated multimodal corridor management including ITS, high-occupancy toll (HOT) lanes, and bus rapid transit (BRT) , along with “new technologies and services including autonomous and connected vehicles, smart parking, vehicle-to-vehicle (V2V) communications, infrastructure-to-vehicle (V2I) communications, and vehicle sharing and ride-sharing services.”<sup>3</sup>

### Strategic Management Plan

The Caltrans Strategic Management Plan (2015-2020) focuses on the philosophy of “preserving, maintaining and operating the existing transportation infrastructure”. It effectively addresses the operations-related vision identified in the CTP through the following goals and related objectives<sup>4</sup>:

1. **Safety and Health:** Provide a safe transportation system for workers and users and promote health through active transportation and reduced pollution in communities.
2. **Stewardship and Efficiency:** Responsibly manage California’s transportation-related assets.
3. **Sustainability, Livability and Economy:** Make long-lasting, smart mobility decisions that improve the environment, support a vibrant economy, and build communities, not sprawl.
4. **System Performance:** Utilize leadership, collaboration, and strategic partnerships to develop an integrated transportation system that provides reliable and accessible mobility for travelers.
5. **Organizational Excellence:** Be a national leader in delivering quality service through excellent employee performance, public communication, and accountability.

Examples of proposed outcomes through the SMP that are achievable through ITS implementation and enhancement include:

- Reduced traveler and worker deaths (“Zero Fatality”)
- Reduction of transportation system-related air pollution (including greenhouse gases and criteria pollutants)
- Improve measurement and reliability of ITS elements’ health, system operability, and equipment workability

<sup>3</sup> Ibid.

<sup>4</sup> Caltrans Strategic Management Plan, Page 3-4, California Department of Transportation, March 2015



- Increase use of alternative modes of travel (e.g., transit, bicycle, pedestrians)
- Support more efficient and integrated freight transportation operations
- Improve travel time reliability for all modes
- Reduce peak travel delays for all modes
- Provide integrated multi-modal traveler information through integrated management and operations activities
- Improve partnerships between Caltrans and other agencies along with the private sector

While the SMP represents a global view of transportation improvements that are relevant statewide, each region and community may have additional and more specific transportation goals, objectives and strategies that may be reflected within the development of an ITS program. Therefore, it is important to tailor ITS-related planning and policy activities to the consensus regional needs. In conjunction with the SMP-related goals and objectives, these specific needs may be prioritized and specific performance measures defined, whether based on statewide measures or on more specific, regionally relevant measures.

### 1.2 Transportation Systems Management and Operations (TSMO) and the Capability Maturity Model (CMM)

According to the Federal Highway Administration (FHWA), “Planning for Operations is a joint effort between planners and operators to integrate management and operations (M&O) strategies into the transportation planning process for the purpose of improving regional transportation system efficiency, reliability, and options. It requires collaboration among transportation system operators, transit agencies, highway agencies, toll authorities, local governments, and others to facilitate improved transportation system operations. M&O strategies, also known as transportation systems management and operations (TSMO) strategies, are programs, projects, or services designed to get the safest and most efficient use out of existing and planned infrastructure<sup>5</sup>.”

Caltrans has consciously adopted a Planning for Operations approach for planning and operating the state highway system using performance-based systems. In addition, Caltrans Operations has been working to restructure itself to better manage the day-to-day and long-term execution of TSMO strategies. Implementation of ITS and related strategies is a key cornerstone of TSMO, along with companion asset management processes. ITS and asset management processes provide the transportation system monitoring and data collection tools necessary to actively implement TSMO strategies, and in turn measure system performance to ensure TSMO goals are being met.

Caltrans has made strong use of a Capability Maturity Model (CMM) approach to inform its restructuring process to better utilize TSMO strategies for day-to-day operations. The CMM process determines the current state of capabilities and processes required to implement TSMO to its fullest capacity.

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<sup>5</sup> <https://ops.fhwa.dot.gov/plan4ops/about.htm>; accessed September 30, 2017



*Caltrans' Capability Maturity Model for TSMO highlights the importance of developing a statewide approach to developing operations programs and policies, and developing a system and technology implementation approach that incorporates up-to-date ITS architectures. Additional emphasis is on use of outcome-driven performance data to determine benefits and costs of operational strategies, and assuring that TSMO is a widely visible program at the core of Caltrans District activities.*

Caltrans is using CMM guidance published by the American Association of State Highway and Transportation Officials (AASHTO) to measure its capabilities. The AASHTO TSMO Guidance and a CMM self-assessment is on the Internet at <http://www.aashtotsmoguidance.org/>. The AASHTO CMM uses the following business processes as the dimensions to be measured:

- Business Processes (Planning and Programming) – including planning, programming, and budgeting (resources)
- Systems and Technology – including use of systems engineering, systems architecture standards, interoperability, and standardization
- Performance Measurement – including measures definition, data acquisition, and utilization
- Culture – including technical understanding, leadership, outreach, and program legal authority
- Organization / Staffing – including programmatic status, organizational structure, staff development, and recruitment and retention
- Collaboration – Partnerships among levels of government and with public safety agencies and private sector

The dimensions of capability are essential and interrelated, and they all require executive support and leadership. Importantly, advancing the above processes also involve coordination with the various stakeholders and partners, particularly at regional levels where multi-modal corridor improvements frequently entail collaboration with metropolitan planning organizations (MPOs), transit agencies, local transportation departments, and others.

The capabilities are measured as follows, in which the degree of commitment and capability increases with each increase in level number:

- Level 1 – Performed
- Level 2 – Managed
- Level 3 – Integrated
- Level 4 – Optimizing

In simple terms, the higher the capability measurement (Levels 1 through 4) in a particular business processes, the more mature is the capability of the organization in that particular process. Taken collectively, the higher the capability measurement scores in all of the business processes combined, the more mature are the capabilities overall in the observed program – in this case TSMO for Caltrans. The objective of capabilities measurement, and the push to improve and expand capabilities, leads to a culture of continuous improvement of operations and system reliability.

Caltrans is charting its course toward more mature TSMO capabilities as illustrated in Figure 2. The figure provides a “snapshot” in time, but points to a steady process toward an integrated approach to operations, with optimization of these integrated capabilities a natural follow-on. Paramount to achieving this integration is interagency coordination, discussed extensively in the next section. Such integration involves not only technology deployments, but also operational procedures and management activities, as well as planning and program development.

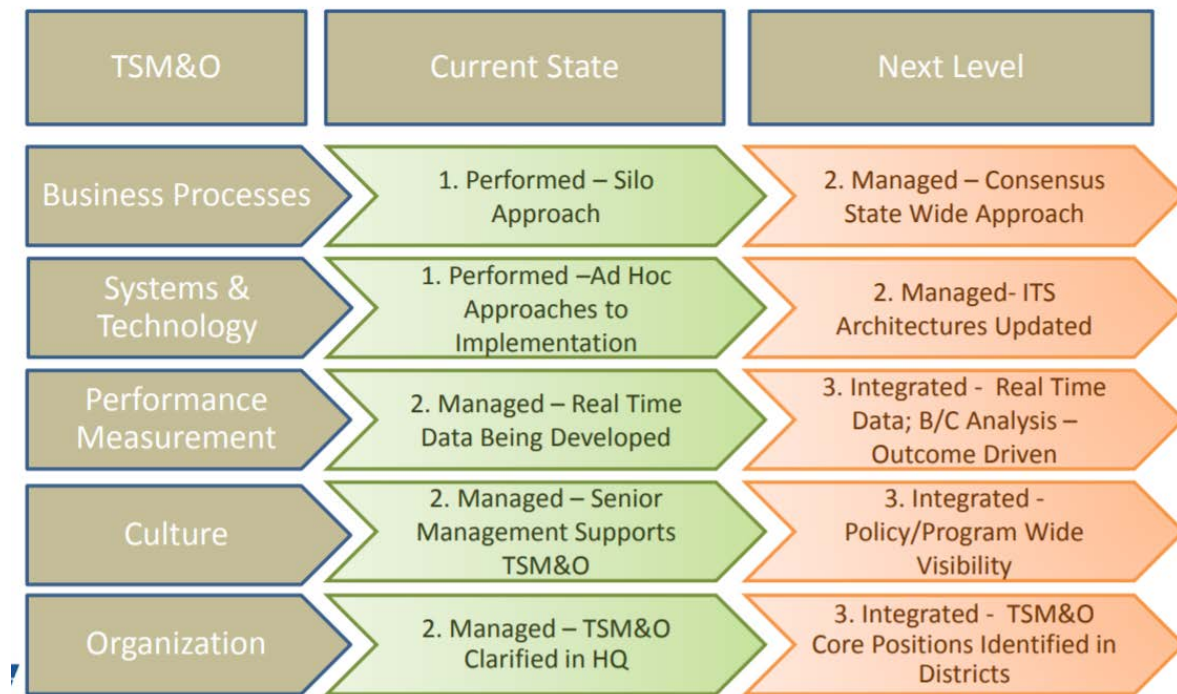


Figure 2. TSMO Process States (2013 “Current” State and Path Forward)  
 (Caltrans Regional Operations Forum, July 2016, “TSMO Caltrans Statewide Perspective”, Nick Compin)

### 1.3 Interagency Coordination in ITS Planning and Deployment

Because of the importance of ITS in Planning for Operations and TSMO, and the active paradigm shift underway at Caltrans, it is more important than ever that ITS be methodically planned and implemented in a multi-agency, collaborative manner involving planning, operations and technology personnel. The various multi-modal applications of ITS often cut across agency, regional and even Caltrans District boundaries, further reinforcing the need for interagency collaboration.



*A methodical approach to ITS planning and implementation should not only achieve maximum interagency coordination, but to the greatest degree possible, a reduction in duplication of efforts. With Caltrans being a stakeholder in every regional ITS architecture in the state, Caltrans is in an important leadership position to collaborate as a partner on regional ITS plans and architecture development and maintenance activities throughout California.*

*In addition, multi-disciplinary representation is essential in the planning process, involving not just planners but also operations and information technology personnel involved in deploying, operating and maintaining the systems, i.e., the staff working directly with transportation management systems and services.*

### 1.3.1 Regions and Caltrans Districts

Most ITS planning is accomplished at the regional level. To this end, it is essential to carry out coordination between Caltrans Districts, Metropolitan Planning Organizations (MPOs) and other regional stakeholders. Of interest is that some MPO areas have more than one Caltrans District while some Caltrans Districts may encompass more than one MPO. This means there is no one single “template” for coordination of planning and deployment of ITS initiatives. Rather, it is important to understand the processes for advancing ITS in each region, which may differ from one another. ITS projects and strategies can help regions achieve their larger regional planning goals and objectives, and coordination with Caltrans is of value not just because of the Department’s roles and responsibilities within each region, but through the ability to leverage opportunities brought by various statewide operational and funding initiatives.

In general, MPOs in California have been in the lead role for development and maintenance of regional ITS architectures (RITSAs). Depending on the size and institutional complexity of a given region, there may be sub-architectures (e.g., county-level architectures), or perhaps overlay architectures (e.g., transit-focused, arterial-focused) that compose the RITSA. This introduces a degree of complexity for MPOs as well as Caltrans Districts in terms of coordination with various agencies on ITS architecture activities and project initiatives.

For example, in Southern California, county-based transportation authorities or commissions develop their own RITSAs focusing on county elements, while the Southern California Association of Governments (SCAG) develops a multi-county RITSA focusing on regional or cross-county elements that integrate with the county-level RITSA activities.



To add to the complexity, SCAG also encompasses more than one Caltrans District, including all or portions of Caltrans Districts 7, 8, 11 and 12. Several Caltrans Districts encompass more than one MPO. (For example, District 11 overlaps with both the San Diego Association of Governments [SANDAG], and SCAG, which includes Imperial County.)

In rural areas of California not within the boundaries of an MPO, Caltrans has often taken the lead in ITS architecture development and maintenance. Where possible, Caltrans has typically done this on a multi-county basis to promote collaborative ITS planning and implementation.



*It is incumbent upon regional ITS architecture developers within MPOs or other lead agencies to include Caltrans as integral members of the architecture development stakeholder group, as well as architecture maintenance team. However, it is also important for both Caltrans District planning and operations staffs to provide consistent input to the MPOs and other entities developing and maintaining ITS architectures.*

In particular, the development and implementation of Connected Corridors by Caltrans and partner agencies provides an excellent opportunity to leverage the institutional relationships needed for architecture development and maintenance activities. The cooperative operational concepts associated with the Connected Corridors program can provide the impetus for improved interagency coordination and cooperation in the development and maintenance of ITS architectures. Agencies participating in Connected Corridors activities are in a good position to understand the need for early collaboration at the ITS architecture development stage as well as throughout program development, deployment and operational life cycle. Chapter 2 addresses the synergy of planning, architecture and development in further detail.

Likewise, implementation of standards and guidance for Connected and Automated Vehicles (CAVs) (including vehicle-to-infrastructure (V2I) communications, charging stations, preferential operational strategies for autonomous urban and freight vehicles) requires close coordination and working relationships to assure consistency between partner agencies and Caltrans.

Methods of coordination between agencies can include, but are not limited to the following:

- Stakeholder Working Groups associated with specific technical areas within the region, e.g., traveler information, incident management, or other areas defined as part of regional TSMO activities
- Workshops and charrettes involving program development activities that engage planning and operations staffs – these could focus on various subareas of interest within the region,



and may be especially appropriate when targeting CAV initiatives as well as corridor activities, major construction projects, etc.

- Monthly webinars and coordination activities in between the workshops/charrettes that focus on progress within ITS planning and architecture activities as well as topics of interest to the group.
- Identification of joint program funding opportunities such as USDOT’s Active Transportation and Congestion Management Technologies Deployment (ATCMTD) program and Caltrans’ SB1 funding for “Congested Corridors”. This would require prior development of ITS planning and regional ITS architecture elements showing how the project is integrated and part of the core vision of the region. (See also Chapter 3 of this Guide.)



*Development of ITS programs and projects should offer traceability both to the CTP 2040 plan as well as regional transportation goals and objectives. In turn, agency transportation managers should assure that the TSMO needs, as a core element of transportation services, are reflected in regional transportation planning. Statewide and regional performance measures to determine the effectiveness of strategies should also be considered in the definition and development of ITS programs.*

### 1.3.2 Statewide

Taken in the context of the full statewide ITS program, regional activities (including both local agencies as well as Caltrans Districts) serve as the building blocks of the program, guided by both statewide and regional goals and objectives. As discussed in Section 1.1, CTP 2040 has effectively codified ITS solutions as part of the overall mobility toolkit. The SMP has identified specific goals, objectives and outcomes. While much of the effort to deploy ITS is focused on regional strategies (and within Caltrans, District initiatives), additional activities at the statewide level will be needed to assure standardization activities occur where needed, as well as programs and projects not otherwise defined at the regional level but essential to statewide operations (e.g., interregional interfaces). This would notably include development of an updated SWITSA as is discussed in more detail in Section 2.4.

The relationship between regional ITS planning, architecture, and statewide ITS programming activities is further addressed in the context of Senate Bill 1, The Road Repair & Accountability Act of 2017. This legislative package invests fuel taxes and other transportation-related fees to fix roads, freeways and bridges and puts more funding toward transit and safety in communities across California. These funds will be split equally between state and local investments. SB1 defines specific



program activities for operations and congestion management that include the following program areas that are relevant to ITS:

- Congested Corridor Program (\$250 million annually)
- Freeway Service Patrols (\$25 million annually)

Caltrans District-level Operations projects at the district level may be included in the Statewide Highway Operation and Protection Program (SHOPP), typically as a Long Lead program within the SHOPP Ten Year Plan. ITS projects may be included as “anchor” (or primary projects) as well as for inclusion as part of other projects, consistent with District targets. Thus, SHOPP may serve as a road map for operations investments, and is thus emerging as a road map for containing ITS and technology related improvements. Each project definition should include definition of specific outcomes and performance measures. Annual SHOPP project lists are developed one or more years in advance of expected funding allocations for projects contained in the SHOPP Ten Year Plan.

Chapter 2 of this Guide presents a view of how statewide ITS planning and architecture activities can implement the statewide vision. Chapter 3 addresses how these ITS planning and architecture activities should be used to define programs and projects that can be implemented.

## 2. ITS Planning and Architecture Development

Transportation problems in each region and highway corridor need to be analyzed in more detail before establishing any specific projects as their solution. In California, regional-level and interregional transportation planning processes include **system planning** and **regional planning**. System planning generally applies to the long-range needs of the State Highway System and is performed on a Caltrans District level; regional planning focuses on the broader transportation network within a region. Within this framework, the 10-Year SHOPP Plan is considered a special planning activity that addresses needs at the Caltrans District level, but on a statewide basis. Generally, the traditional transportation planning process focuses on estimating needs and allocating federal, state and local funds to provide solutions to meet needs as budget allows.



*Many ITS initiatives have been developed independent of regional planning activities, often driven by national funding or research initiatives that identify opportunities not previously addressed. While the flexibility to identify and develop such programs is laudable, it may not fully consider the integrated view of transportation operations that is the key to improving mobility and safety, as well as standardizing particular elements. The latter is of keen interest as connected and automated vehicle technologies emerge and connected infrastructure becomes critical.*



Through use of a regional ITS architecture framework, regional transportation planning agencies can enable discussions among multiple jurisdictions and stakeholders by coordinating the needs of the entire transportation system rather than focusing on specific projects. It is nationally recognized that:

*Regional ITS Architectures are (a) tool that can be used to help mainstream operations into the planning process. 23 CFR 940.5 requires that Regional ITS Architectures be “consistent with the transportation planning process for Statewide and Metropolitan Transportation Planning” and that a broad cross section of agencies involved in transportation operations, including highway agencies, public safety agencies, transit operators, and others be included in the architecture development process. Since the Architecture requirement took effect in 2005, over 300 regional ITS Architectures have been developed and many continue to be updated in accordance with Federal requirements.<sup>6</sup>*

Architectures also bring together a diverse range of stakeholder perspectives – multi-modal transportation-related stakeholders are of course critical, but the architectures also allow for considerations for law enforcement, commercial vehicles, emergency management, tourism, and traveler services, among others. Specific reasons for leveraging regional ITS architectures for planning for operations activities, as identified by FHWA<sup>7</sup>, include the following:

***Integrate and coordinate the technology underlying operations services:*** *Planning for operations without the support of a regional ITS architecture risks poor integration of ITS across the region. The regional ITS architecture facilitates the integration and coordination of compatible ITS across a region so that related projects are implemented more efficiently and travelers experience seamless transportation services as they travel across multiple jurisdictions.*

***Align efforts to make greater progress in ITS and operations:*** *By aligning the regional ITS architecture with the operations goals, operations objectives, and management and operations strategies in the metropolitan or statewide transportation plan, planning for operations and the regional ITS architecture can reinforce each other and make greater strides together toward improving safety, efficiency, and reliability.*

***Use existing resources smartly:*** *A regional ITS architecture that does not support metropolitan or statewide planning, programming, and implementation of operations programs and projects has an extremely limited impact after the initial collaborative benefits of regional ITS architecture development fade. This represents a significant opportunity loss. Connecting the*

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<sup>6</sup> Applying the Regional ITS Architecture to Support Planning for Operations, FHWA-HOP-12-001, FHWA, February 2012, page I (cover letter)

<sup>7</sup> Ibid.. page vii

architecture to planning reduces the duplication of effort that goes into both developing the regional ITS architecture and planning for operations.



*In many cases, the transportation planning process occurs before any effort is made to create or develop regional ITS architectures or even ITS-focused strategic plans. As such, traceability is required for architecture-defined ITS services, or of ITS programs and projects in a strategic plan, to overarching goals and objectives, whether they be the CTP or regional / local efforts.*

## 2.1 Regional TSMO / ITS Strategic Plans

Regional transportation planning typically focuses on the transportation network within a Metropolitan Planning Organization (MPO) or Regional Transportation Planning Agency's (RTPA) planning area, including highways, local arterials and transit systems. Planning activities may include corridor studies, transit plans, county, metropolitan or regional transportation plans. While many of these plans provide a high-level definition of goals, objectives, operations and technology strategies, they often focus on the facilities themselves and the nature of improvements needed to these facilities. As such, ITS is not always incorporated explicitly into planning activities except in a higher-level fashion.

Caltrans has embarked on a process to tie planning and TSMO more closely. The planning process for ITS should include, at the minimum, representatives of public agency transportation planning, operations and information technology (IT) services, as well as private sector partners and research entities involved in development of shared mobility and CAV activities and applications. ITS strategic plans and Regional Concepts of Transportation Operation (RCTO) are examples of initiatives that can provide a basis for definition of programs and projects that fulfill the regional transportation vision, and in general focus on TSMO activities, but may also take into account shared mobility and transit operations, as well as other multimodal considerations. These activities include many applications that rely on ITS technologies. Additionally, the emergence of CAVs in coming years will further influence TSMO.



Definition of specific TSMO strategies of interest may differ between regions, but typically may include the following<sup>8</sup>:

- Traffic Incident Management
- Work Zones
- Planned Special Events
- Road Weather Management
- Traffic Management

TSMO activities should be an integral part of transportation plans, in order to support longer-term operational needs, performance goals and objectives, and address cross-cutting activities needed within agencies and between agencies.<sup>9</sup>

#### 2.1.1 Identification of TSMO Programs and Projects

Two types of documents may be developed to identify planned ITS programs and projects in light of overall transportation planning activities.

- **A Regional Concept for Transportation Operations (RCTO)**, whether done by an MPO, local agency, or Caltrans, may develop a needs assessment and potential programs involving one or more of the operations strategies such as those listed above. The RCTO may cover a broad geographic area, targeted corridors (e.g., Connected Corridors), or a specific operational entity such as a Caltrans District. It is noted that while ITS is a key subset of tools within a RCTO, perhaps the largest subset, not all RCTO recommendations specifically identify technology solutions. Some may be policy and procedural solutions and may involve institutional changes.
- Knowing that an **ITS Strategic Plan** is a tool within the TSMO framework, the plan is typically developed at a regional (i.e., MPO or transportation authority) level, but may be developed by individual agencies in support of their capital planning process. In addition to what may be contained within an RCTO, the plan may address traveler information services, freight operations, transit, and other functions that fulfill the broader needs of the region or agency developing the plan.

Other studies, including short-range transit plans, countywide transportation plans, and regional transportation plans, may include ITS components that tie to overall regional or agency goals and objectives. Whether or not an RCTO or ITS Strategic Plan has been completed in a region, other studies that specifically address ITS elements should also be considered as inputs to RITSA activities as discussed later in this section.

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<sup>8</sup> Improving Business Processes for More Effective Transportation Systems Management and Operations, FHWA-HOP-16-018, USDOT, Federal Highway Administration, Strategic Highway Research Program (SHRP2 Solutions), and American Association of State Highway and Transportation Officials, January 2016.

<sup>9</sup> Ibid.



Regardless of the approach utilized within a region to plan operations and technology projects, the following should be key components of the definition of ITS program and project activities for a region, agency, corridor or Caltrans District at a planning level:

- 1) **Define the motivation for operational improvements using TSMO strategies.** *It is critical to define the high-level vision for operational improvements by understanding the underlying transportation goals and objectives for the region.*
  - **INPUT: High-Level Needs:** The overall goals, objectives and needs for transportation activities are defined at the highest level and are the initial input into the ITS planning process.
  - **OUTPUT: Operations or ITS Objectives:** Objectives that are focused on particular operational or informational improvements related to congestion, reliability, information, or other functions are to be developed and mapped to the regional, agency or corridor needs, and can serve as inputs into continued updates to the regional planning process. These may be further subdivided into particular operations or ITS **strategies** (e.g., traffic management, work zones, traveler information, and transit operations) relevant to the high-level needs.
  
- 2) **Build upon the operational objectives and develop an overall approach for each of the strategies defined above.** *Starting with regional performance measures based on the corresponding regional goals and objectives, a series of programs and project should be defined that can incrementally implement the desired system functionality to achieve the desired benefits.*
  - **INPUT: Performance Measures:** As in any TSMO strategy, programs and projects identified through ITS planning activities should support specific performance measures identified at the high-level planning process. Such measures may relate to congestion (including travel times, travel time reliability, vehicle-miles traveled, vehicle-hours traveled), safety (accident frequency and severity, high-accident locations, etc.), demand management (including mode choice, number of trips taken by shared modes, non-motorized vehicles, etc.), and other measures. These performance measures should be mapped to the particular TSMO strategies.
  - **INPUT: High-Level Strategies / Recommendations from Overall Planning Process:** The input from the general transportation planning process should provide particular high-level strategies supporting system needs. For example, the CTP 2040 has identified specific policies that fulfill particular goals. For example, the goal to “Improve Multimodal Mobility and Accessibility for All People” has three policies defined, one of which is “Manage and Operate an Efficient Integrated System:” Specific technology recommendations identified in the plan include ITS, HOV lanes, road pricing, smart parking, V2V and V2I communications, promotion of ridesharing and vehicle sharing, etc. These recommendations should be mapped to the particular TSMO strategies.



- **OUTPUT: Short-Term ITS/TSMO Programs and Projects:** Within each of the particular TSMO strategies, programs and projects should be defined. For example, one short-term strategy may include upgrading of arterial traffic management systems. The strategy may include distinct projects including introduction of adaptive traffic management controllers and control systems, upgrade of an operations center, and introduction of decision-support systems that incorporate information from freeway or transit management systems that may assist in optimizing arterial operations under all conditions, with a focus on maximizing traveler throughput (as opposed to vehicle throughput). Define scope and order-of-magnitude costs.
- 3) **Address relationships and procedures needed to implement the recommended strategies.** *Knowledge and details associated with current agency responsibilities, cooperation and relationships are critical at this stage. The existence of a RITSA is useful in this regard in establishing what the existing connectivity is. If a RITSA is not yet developed, then these relationships and procedures need to be documented within the ITS plan or RCTO and incorporated within the RITSA.*
- **INPUT: Operations Funding Program or Pool:** The regional and statewide transportation planning processes typically result in a definition of a transportation improvement program (TIP). These are often based on “unconstrained” budgets (i.e., revenues expected to exceed current or projected levels) as well as “constrained” budgets (e.g., revenues expected to be limited or reduced compared to current or projected levels), the latter essentially resulting in higher priority projects ranked higher for program funding. Many TIPs may further categorize improvements by type as well. For Caltrans Districts, input into the SHOPP program is essential. At the same time, knowledge of other funding solutions is highly recommended. Such funding may include Federal or state funding opportunities that have resulted through SB1 at the state level or through the Federal FAST Act of 2015, such as the Active Transportation and Congestion Management Technologies Deployment (ATCMTD) program, Surface Transportation Block Grants (STBG) apportioned to states, Infrastructure for Rebuilding American (INFRA) grants, and other programs. For the most part, Federal funding may cover 60% or less of project costs (for ATCMTD, it is up to 50% of project costs).
  - **OUTPUT: Project Specifications:** “Project specifications” in a planning sense refer to descriptions of the project purpose, scope, and coverage area along with estimated costs including capital, operations and maintenance, etc., and other details for inclusion in the regional TIP or, in the case of Caltrans Districts, the SHOPP. Identify each project under the short-term strategies that may be eligible for funding under one or more programs at the Federal, state or regional level.
- 4) **Resource Arrangements.** *Identification of funding resources and programs are an essential piece of the project descriptions and should be addressed in conjunction with the generation of Project Specifications above.*



- **INPUT: Available Funding Resources:** Address what Federal, State and local funding may be available to support projects along with specific requirements for applying for and using the funding, including funding limits, fiscal year availability, and reporting / evaluation requirements.
  - **OUTPUT: Project Funding Plan:** Leveraging from Project Specifications above, the mechanisms for funding the projects both in terms of capital investment as well as maintenance and operations need to be described, and should take into consideration existing components that would need to be incorporated, updated or replaced regardless of other new project activities (see also below).
- 5) **Physical Improvements.** *Definition of the physical infrastructure and facility improvements required should be defined in coordination with other regionally significant projects, in case there are synergies and some leveraging of other projects that would facilitate deployment of recommended ITS or operations strategies, or that would influence the prioritization of these strategies and related projects.*
- **INPUT: Regionally Significant Projects:** Projects identified in the RCTO or ITS Strategic Plan that are considered regionally significant within a Regional Transportation Plan should be considered to be of the highest priority for deployment, and should also be considered high-priority if they are tied into short term road or transit improvement activities.
  - **INPUT: Caltrans Transportation Asset Management Plan (TAMP):** To maintain the SHS in a state of good repair it is important to address what legacy components may be utilized and whether these need to be upgraded based on life cycle maintenance and reliability concerns as well as technological obsolescence. Consider the resources needed to update existing systems along with funding of new elements.
  - **OUTPUT: Modification of project priorities** based on coordination with other projects and initiatives, along with identification of legacy components associated with project improvements that would require update or replacement.

The above steps from an RCTO/ITS Planning perspective are illustrated in Figure 3.



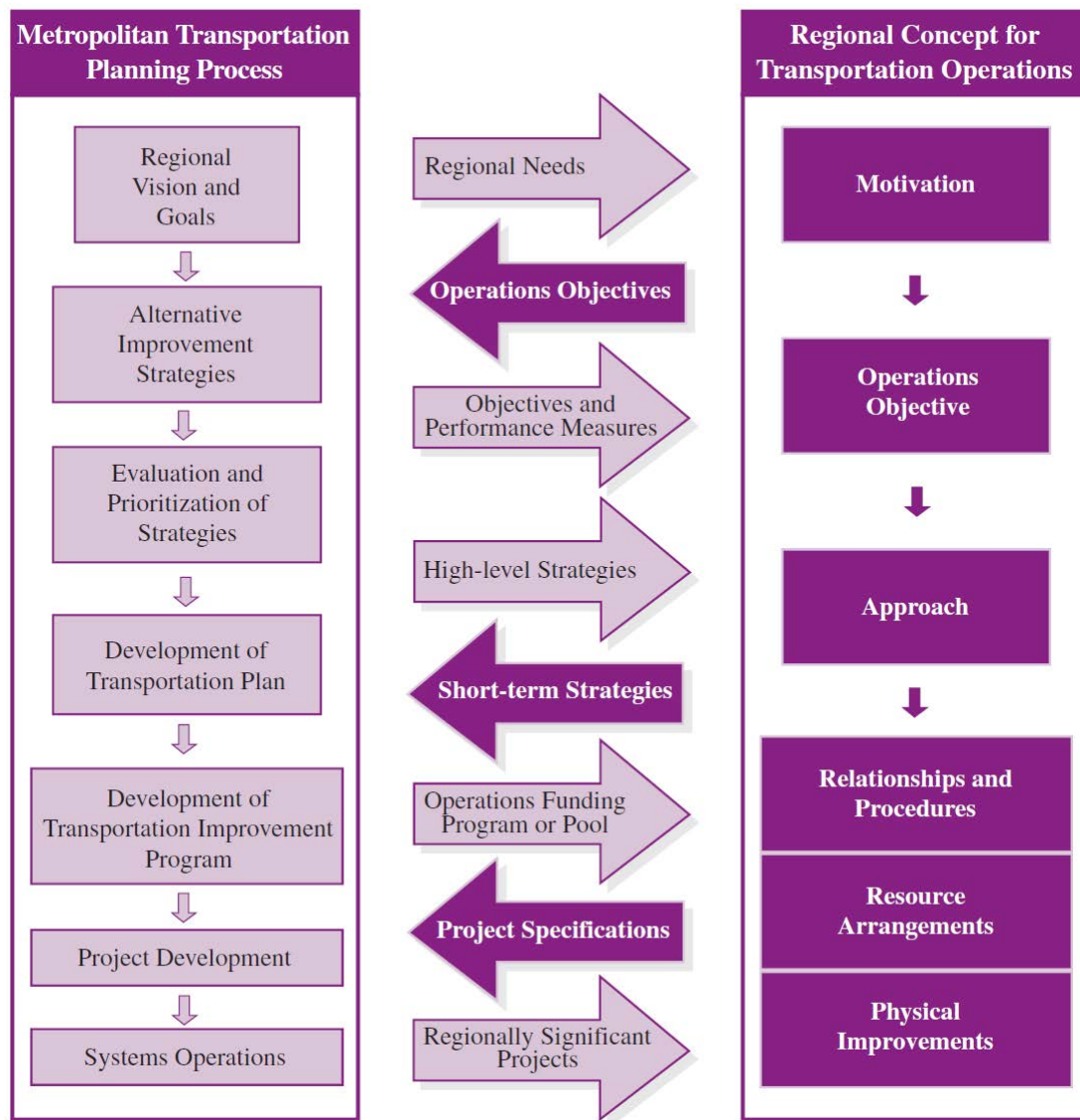


Figure 3. Example of interrelationship between regional transportation planning process and an RCTO, with similar interrelationships expected with an ITS Strategic Plan as well.

### 2.1.1 Relationship of RCTO and ITS Strategic Plans to Regional ITS Architectures

Per FHWA’s RCTO Primer, the RITSA is also valuable as a tool to link a higher-level transportation plan to operations of the transportation system. As with RCTOs and ITS Strategic Plans, the structure of an architecture is based on regional needs, defined potential services to address these needs, and current and envisioned operational roles for specific agencies. While an architecture broadly defines what operations agencies do and their vision for future activities, RCTOs and ITS Strategic Plans identify what services and elements within the architecture are deployed within particular projects.



A region or agency may require develop multiple RCTOs depending on the corridor operational needs and the business areas identified. All of these plans are integral to the development of a regional architecture, and as such, ITS planning activities work best when they are coordinated in their entirety with the architecture. Conversely, and no less importantly, a RITSA may also 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.

## 2.2 Regional ITS Architectures

Regional ITS Architectures (RITSAs) are essential tools in the development of an ITS deployment roadmap in coordination with the transportation planning process, but are also required for Federal funds to be used for ITS activities as specified in 23 CFR 940.9 (Rule 940). A RITSA requires use of the National ITS Architecture.

### 2.2.1 Evolution of ITS Activities

Since implementation of Rule 940 in 2001, much has changed. The National Architecture and its development tool (Turbo Architecture) has evolved over the years to incorporate planning (goals and objectives) and performance measure inputs. Even more critically, ITS has embraced a broader array of services as Connected and Automated Vehicle (CAV) activities have emerged along with the expanded use of road pricing, active traffic management and other applications. Integrated Corridor Management (ICM), often referred to in California as “Connected Corridors”, have become a key basis for deployment of TSMO strategies that are inclusive of ITS activities, in regions.

Of particular significance has been the emergence of the private sector as a leading driver in transportation technology, in most cases finding a market for their services independent of government policies or initiatives. Private sector activities have included development of real-time traveler information and mapping applications on smartphones utilizing a blend of real-time probe and crowd-sourced user data; shared mobility services that allow users the ability to arrange and pay for rides, vehicles or bicycles, again using smartphones; and finally, the development of autonomous vehicle technologies and services. In addition, private sector entities are increasingly serving as builders and operators of road facilities in the US (e.g., toll lanes on existing highway corridors featuring dynamic pricing), in partnership with public agencies.

Identifying mechanisms for public and private sector services to work together and support each other’s functionality will be of critical importance going forward, and will enable public sector agencies to focus their limited resources on services that support management and operations of the transportation system. For example, Caltrans and other public agencies could work with the private sector (e.g., Transportation Network Companies, or TNCs) to share vehicle and travel data, thus supporting the ability of public sector agencies to monitor performance and optimize management and operations of the system.

### 2.2.2 Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)

Unveiled in July 2017, the USDOT’s Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) incorporates the scope and content from both National ITS Architecture and the Connected Vehicle Reference ITS Architecture (CVRIA) that came before it, and is developed specifically to incorporate emerging applications, technologies and stakeholders.

ARC-IT provides a common, unifying framework for planning, defining, and integrating ITS, including CAV applications, reflecting the contributions of a broad cross-section of the ITS community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.). It provides a common basis for planners and engineers with differing concerns to conceive, design and implement systems using a common language as a basis for delivering ITS, but does not mandate any particular implementation<sup>10</sup>. As before, the architecture develops a framework that is independent of technologies or products, though cognizance of the current and emerging technologies is useful in developing this framework.



*Of critical importance is the training of not only planning but also operations and technology staffs from different public and private sector entities in the use of ARC-IT and its connectivity to other regional and agency planning and deployment activities. This will assure that a RITSA has multiple champions from different backgrounds and stakeholders within a region, assuring that the RITSA is maintained and updated on a regular basis as new projects are deployed and new applications are implemented.*

The relationships of systems in ARC-IT have advanced beyond the traditional “sausage diagram” that has previously provided the high-level description of how architecture components were connected. Figure 4 describes a high-level physical view of ARC-IT containing Physical Objects (systems) that include **Center**, **Field**, **Traveler** (including portable/handheld devices), **Vehicle** (including built-in information and safety systems), and **Support** (including security, communications management, etc.). The Physical Objects are connected using a variety of wireline and wireless interfaces that included center-to-center, center-to-field, and short-range wireless (including V2I, V2V and V2X).

Together with its development tools (discussed below), ARC-IT addresses many of the past concerns expressed by stakeholders relative to RITSA development in California, notably limited relevance to transportation planning activities as well as limited usefulness for incorporation into systems engineering and deployment activities carried out by operations and technology professionals. One other concern has been the ability to keep trained agency staff in order to update and maintain the RITSA.

<sup>10</sup> <http://local.iteris.com/arc-it/>

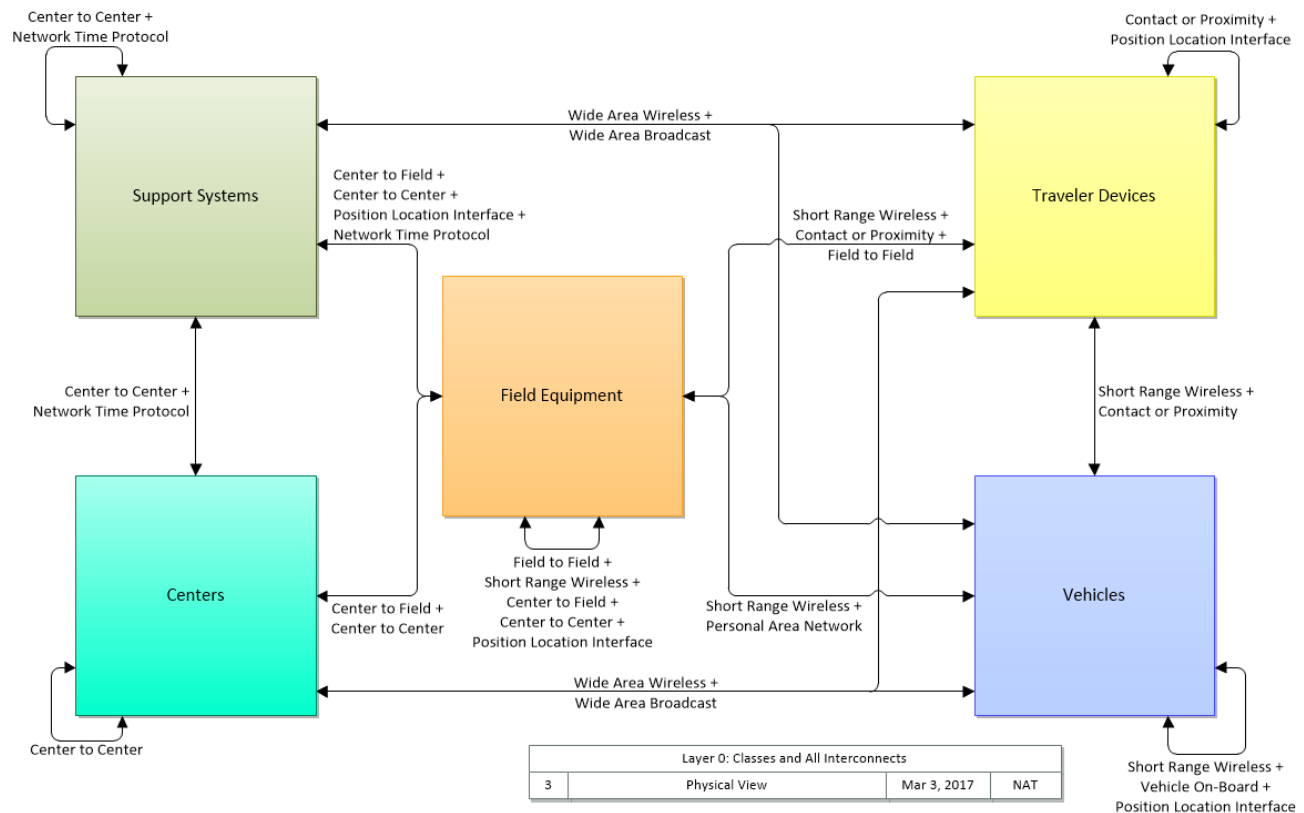


Figure 4. Enhanced Physical View of ARC-IT, Including Systems (“physical objects”) and Communications Interfaces

### 2.2.3 Architecture Tools

Two tools implemented through ARC-IT support both high-level planning and more detailed systems engineering and deployment activities. The tools include:

- **Regional Architecture Development for Intelligent Transportation (RAD-IT)**, a software application that supports development of regional and project ITS architectures using ARC-IT as a starting point. RAD-IT replaced the legacy Turbo Architecture Software and includes all the old Turbo Architecture capabilities in a new, more modern interface<sup>11</sup>, with a focus on providing a definition of services and institutional relationships (including private sector entities and roles) as well as mapping to planning and programming activities that make the tool an appropriate companion to ITS programming and planning activities. RAD-IT links planning goals and objectives, ITS services, standards, physical and communications architecture layer descriptions along with high-level requirements.
- **Systems Engineering Tool for Intelligent Transportation (SET-IT)** provides a single software tool that integrates drawing and database functions with the ARC-IT so users can develop project architectures containing subsets of systems, services and interfaces in the ITS

<sup>11</sup> <http://local.iteris.com/arc-it/html/whatsnew/whatsnewradit.html>

architecture, and develop systems engineering documentation, including concepts of operation and requirements documentation for projects, pilot implementations, test beds and early deployment activities<sup>12</sup>.

#### 2.2.4 Connectivity of ITS Architecture Development to Planning Activities

RITSA development follows a standard process as outlined in “Regional ITS Architecture Guidance: Developing, Using and Maintaining an ITS Architecture for Your Region”, FHWA-HOP-06-112, USDOT, Version 2.0 - July 2006, or latest update. The RAD-IT tool described above is designed to incorporate this process, but incorporates several key newer elements including the input of regional/stakeholder goals and objectives in order to identify operations objectives and performance measures, as well as describing an “enterprise layer” defining agency responsibilities, relationships, and agreements that may be needed.



(From: “Applying a Regional ITS Architecture to Support Planning for Operations: A Primer”)

**Opportunities to leverage the regional ITS architecture in support of planning for operations include:**

- Sustain and build on the collaborative relationships from the regional ITS architecture development.
- Consult the architecture to identify available sources of operations data to track measurable objectives.
- Gather information on operations needs from the architecture and ITS stakeholders.
- Examine service packages in architecture when identifying ITS-based M&O strategies.
- Include the architecture as part of the transportation improvement program (TIP) development process.
- Use the architecture’s operational concepts, functional requirements, and other contents to kick-start project development.

The Architectures can support the overall Planning for Operations framework through a regional coordination strategy developed as part of the RITSA process, or, if a RCTO or ITS plans have been developed or updated first, then reflected in the RITSA. Each of the figures below provide a step-by-step process to relating RITSAs and the planning process with a core focus on TSMO activities, as follows:

- Figure 5<sup>13</sup> reflects the development of an architecture prior to the update of a Statewide or Metropolitan Transportation Plan, corresponding to a Regional Transportation Plan (RTP) as defined earlier. The architecture thus serves as a critical resource in identifying ITS programs

<sup>12</sup> <http://local.iteris.com/arc-it/html/resources/setit.html>

<sup>13</sup> Applying a Regional ITS Architecture to Support Planning for Operations: A Primer, FHWA-HOP-12-001, USDOT, February 2012



and projects for incorporation into the RTP. A RITSA developed without the benefit of an RTP still provides an important framework for coordination between the stakeholders who would also be involved in the planning process, and thus it is important to understand the regional vision as well as agency visions even if overall transportation goals and objectives have not been developed, updated or refined. Performance needs and metrics need to be identified as part of the architecture definition, and incorporated into later RTP activities as appropriate.

- In numerous cases, RITSAs are developed or updated after the RTPs (per Figure 6). In this case, the RITSA process should leverage from defined goals, objectives and strategies that in the RTP, along with related performance needs and metrics. More specific TSMO needs and metrics may be defined for the architecture, whether as part of the RITSA development effort itself, or through an RCTO or ITS Strategic Plan as defined in Section 1 that serves as an input to the architecture. The other key aspect is that the programs and projects defined as part of the planning process (whether directly from the RTP or through a RCTO or ITS Strategic Plan) are used to inform the RITSA development activities and define the stakeholder roles and relationships needed.
- A transportation plan for a state or region may also be developed in coordination with the architecture development process (per Figure 7, with the steps in the process presented in Figures 8A and 8B). While such an effort is ideal in many ways, it also requires a significant amount of collaboration in the beginning between planning and operations staffs from the various public agencies involved in the process. Operations objectives, system performance metrics, and program strategies can be defined in a coordinated fashion that reduces duplication of effort between RITSA and RTP activities, with operations programs and projects defined in an integrated fashion involving both operations and planning personnel in the different stakeholder agencies.

### EXAMPLE 1: ITS ARCHITECTURE SERVES AS INPUT TO PLANNING PROCESS

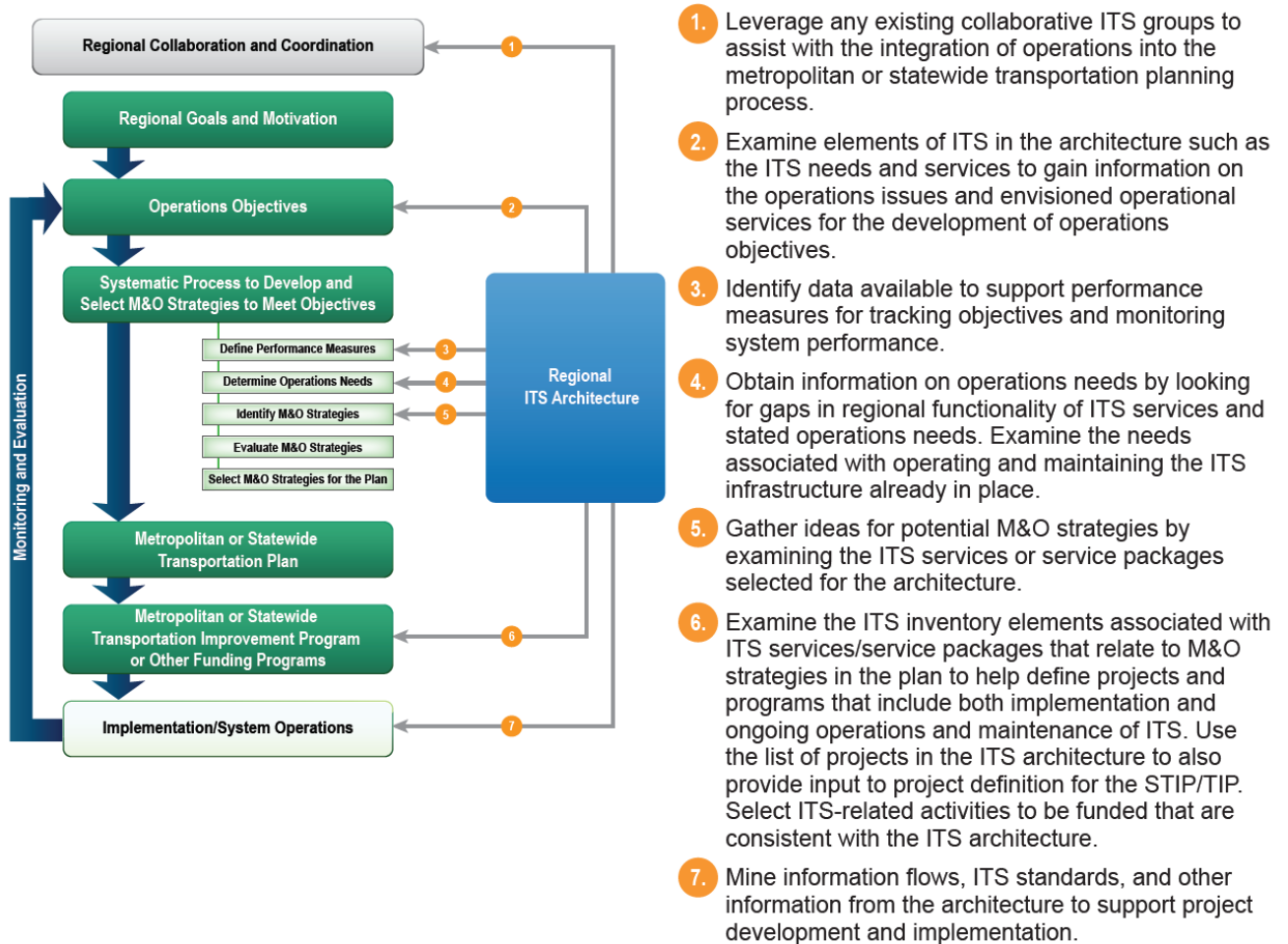


Figure 5. The Use of a Regional ITS Architecture Updated Prior to a Planning Update  
 (From: "Applying a Regional ITS Architecture to Support Planning for Operations: A Primer")

### EXAMPLE 2: PLANNING PROCESS SERVES AS INPUT TO ITS ARCHITECTURE

1. Leverage any regional operations planning groups to support the ITS architecture update.
2. Identify goals and operations objectives from the transportation plan to direct the decisions made in the architecture update.
3. Adopt and update the system performance needs defined for the region during the development of the plan.
4. Select service packages or services that correspond to M&O strategies selected for the plan.
5. Incorporate archived data services and appropriate flows in the architecture to support performance measures selected to track operations objectives and system performance.
6. Update the ITS inventory, interconnects, and information flows to account for any newly planned M&O/ITS programs and projects.

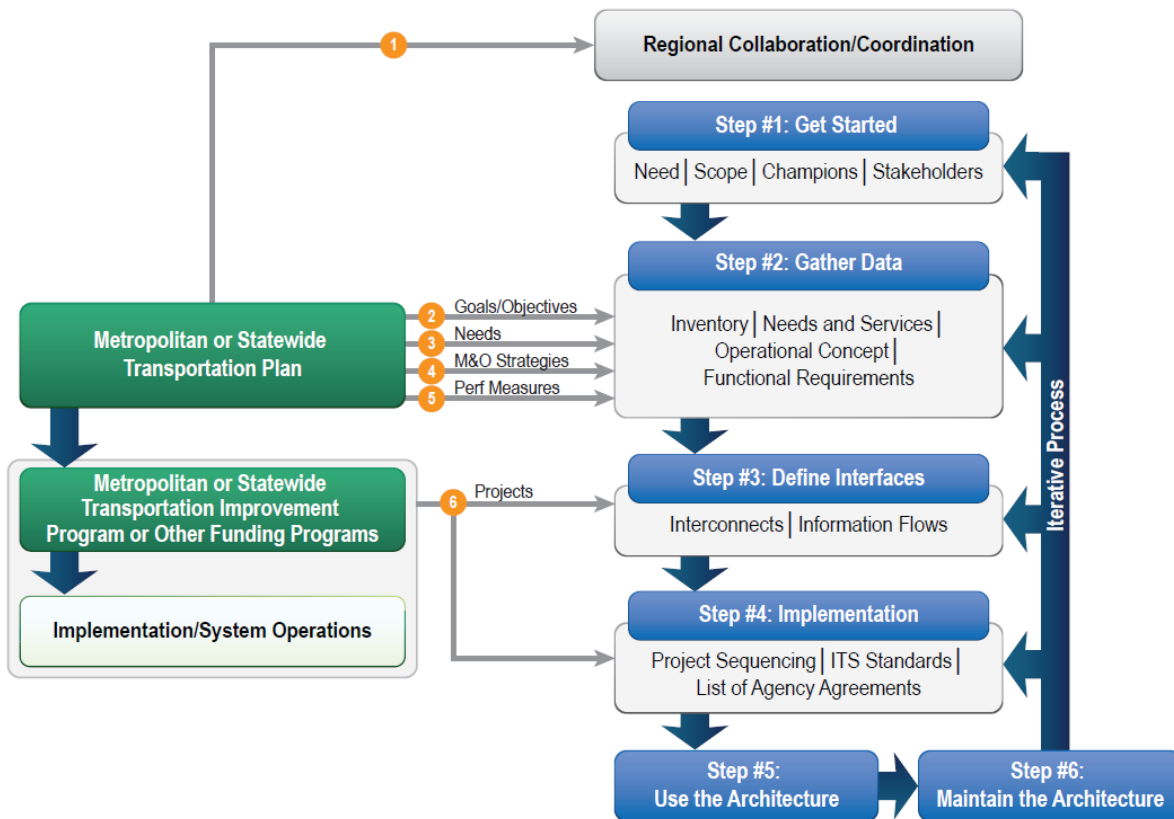


Figure 6. The Use of a Regional Transportation Plans and Studies as an Input to RITSA Development  
 (From: “Applying a Regional ITS Architecture to Support Planning for Operations: A Primer”)



EXAMPLE 3: COORDINATED ITS ARCHITECTURE DEVELOPMENT AND PLANNING PROCESS

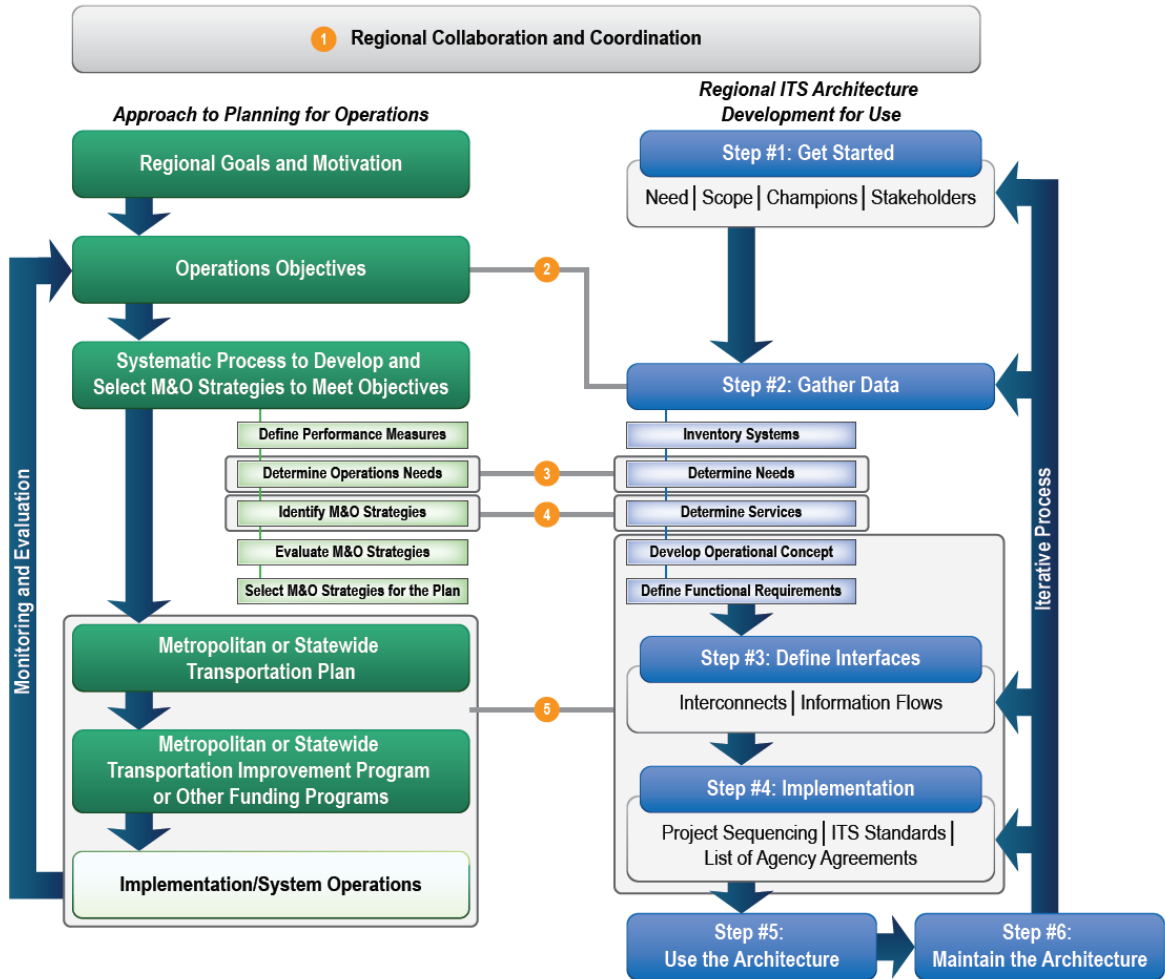


Figure 7. Coordination of RITSA and Regional Transportation Planning Updates, with 5 Connections (refer to Figures 8A and 8B)  
 (From: "Applying a Regional ITS Architecture to Support Planning for Operations: A Primer")

### 1. Regional collaboration and coordination.

The processes are conducted by overlapping groups of transportation operations and ITS stakeholders including staff from planning agencies, State and local road operating agencies, transit agencies, public safety, and others. In many cases, the same regional committee that supports the regional ITS architecture can also support planning for operations, leveraging the overlaps and opportunity for synergy between the two activities. The composition of the staff may shift from management to technical as the work moves from strategic to implementation. In many regions, though, the same individuals at an agency focus on integrating operations into the planning process and developing the regional ITS architecture. Leveraging the same agencies, if not the same individuals, for both processes yields benefits in terms of knowledge transfer and outreach requirements.

### 2. Operations objectives and gather data.

In the second step of the regional ITS architecture development, gather data, several significant activities occur that should both influence and be influenced by the development of operations objectives. It is critically important for connecting the two processes that the operations objectives guide the identification of needs and services in the architecture. This will be discussed in several places in the primer. The systems inventory conducted early in the architecture development can provide useful information on the available sources of operations data that could be used to track measurable objectives. Data availability is a significant factor in establishing specific objectives. In addition, the operations expertise of the stakeholders brought together for the regional ITS architecture should be leveraged in setting the direction for operations in the region.

### 3. Operations and system performance needs.

The regional ITS architecture update calls for the stakeholders to “determine needs and services.” This task is fundamentally a planning task that should be coordinated with the overall transportation planning process. When the plan and architecture are updated at the same time, these parallel activities can be combined for a more coherent and efficient process. When combined, the operations needs of the transportation system can be identified once based on the regional operations objectives and overall goals and used in both the update of the architecture and planning for operations to drive the identification of operations solutions.

*Figure 8A. Steps 1-3 for Coordinated RITSA and Transportation Plan Development  
(From: “Applying a Regional ITS Architecture to Support Planning for Operations: A Primer)*

#### 4. M&O strategies and ITS services.

Identifying M&O strategies to include in the metropolitan or statewide transportation plan is parallel to the “Determine Services” task of the ITS architecture update. Many aspects of these two processes can and should be combined for the sake of efficiency and consistency. The ITS services identified for a regional ITS architecture are selected from a comprehensive menu of “service packages” and there is considerable overlap between service packages and M&O strategies. The exceptions include those M&O strategies that are not based on ITS and the ITS services for improved safety, environment, and others without an operations focus.

M&O strategies are evaluated and selected for inclusion in the transportation plan, at least at the metropolitan planning level. To enhance coordination with the overall planning process, the regional ITS architecture may include those services that are planned or currently existing. Where there are differences, the regional ITS architecture could indicate which services are explicitly included in a plan.

#### 5. Defining and implementing operations programs and projects in a regionally integrated context.

The operational concept, functional requirements, and interfaces that are defined in the regional ITS architecture can be used to improve understanding of the integration needs and dependencies between projects. The detailed definition of each project in the regional ITS architecture helps to identify the scope of an operations project or program and the roles and responsibilities for implementing ITS as well as operating and maintaining it over the long-term.

Developing a schedule for program and project funding as part of the STIP or TIP development can also be performed in conjunction with project sequencing in the regional ITS architecture. The list of projects arising from the regional ITS architecture should be consistent with the sequence of projects and programs in the STIP/TIP.

During project development and implementation, the interconnects, information flows, list of agency agreements, and ITS standards of the regional ITS architecture should be mined for input.

*Figure 8B. Steps 4-5 for Coordinated RITSA and Transportation Plan Development  
(From: “Applying a Regional ITS Architecture to Support Planning for Operations: A Primer)*



### **2.3 ITS/Operations Implementation Planning**

Once Regional ITS Architectures and transportation plans are developed (including regional plans, ITS strategic plans and RCTOs), implementation planning is essential. An ITS Implementation Plan details the appropriate high priority ITS projects, including include goals and objectives, performance measures to be addressed, scope and costing. In conjunction with this effort, systems engineering activities utilizing SET-IT are initiated to apportion those parts of the RITSA associated with given projects. Finally, review of legacy systems and components should address life cycle operations and maintenance issues, as well as functional adequacy, consistent with Caltrans or other operating agencies' asset management activities.

From a Caltrans perspective, Districts are in the best position to assess their needs and identify promising projects as well as current system needs. From a regional perspective, non-Caltrans projects are assessed by the agencies that would operate the project.

Strategies (e.g., Connected Corridors) involving multiple agencies require joint efforts on the part of Caltrans, local and regional agencies who operate different parts of the system. In order to firm up roles, responsibilities and interfaces. Development or updating of RITSAs to reflect such integrated efforts can help facilitate this coordination process. The Regional ITS Architecture process, as has been discussed earlier in this guide, is a tool that both requires and encourages collaboration between agencies when done correctly.

Each region should have an established process for documenting and procuring ITS projects, and may use a variety of procurement options. These can range from on-call / task order-based consultant or contractor services to system management procurement (including a dedicated integrator overseeing and coordinating vendor activities and performing integration and testing), design-build activities (becoming common for large-scale projects), and turn-key procurements (including design and supply of hardware and software systems and services), often used for 511 traveler information systems.

### **2.4 Statewide ITS Architecture**

A Statewide ITS Architecture (SWITSA) provides a statewide framework for pertinent standards, services and interfaces that are relevant to all regions, along with definitions of interfaces between regions, and programs/projects that may occur in parts of the state that are outside the realm of an MPO.

To better define the vision of a statewide architecture, it is important to understand the collective vision of regional architecture activities. Caltrans currently utilizes a statewide architecture documentation tool entitled ITS System Builder (ITS-SB). ITS-SB enables the owners of every RITSA in the state to upload their architecture files to a single database and display ITS device locations (using

separate asset GIS files). As the tool is currently compatible with Turbo Architecture and not RAD-IT (although there are some database similarities, revisions to ITS-SB may be required in the future.

Any future update of the current Statewide Architecture (would leverage from current CTP and other statewide planning efforts such as the Ten-Year SHOPP Plan, with a gap analysis activity needed to identify what elements needed for the SHS are currently not addressed by the existing SWITSA as well as the RITSAs already developed throughout the state.



As with RITSAs, the SWITSA would leverage from ARC-IT, with a particular focus on the following common interfaces:

- Connections between Caltrans District and regional transportation management centers
- Connections with statewide performance management and various traveler information systems across the state to enable data sharing between regions and for statewide information applications
- Traffic and incident management standards for intercity routes connecting regions
- V2I, V2V, C2C, and V2X standards required across the state to assure common information sharing and CAV operations anywhere in California, also including connectivity and data exchange requirements with adjoining states
- Addressing of border crossing, customs, and freight operational requirements on a statewide basis

### 3. Programming

Programming is the step in which an evaluation of a proposed project's cost-effectiveness is conducted and funds are committed to specific projects. Transportation projects have various funding sources depending on their priorities and solutions. The projects that are slotted into a particular funding program usually depend on the project's goal, scope, scale, budget and lead agency. Four key programming documents are of particular importance: the State Transportation Improvement Program (STIP), the Regional Transportation Improvement Program (RTIP), and Interregional Transportation Improvement Program (ITIP), and the State Highway Operation and Protection Program (SHOPP).

Selection of ITS projects follows their inclusion into higher-level planning activities and reflection of the project's services and components within a RITSA.



### 3.1 Project Delivery Opportunities through SB 1

SB 1 provides new opportunities for funding ITS projects, including the SHOPP and the Solutions for Congested Corridors programs. The project nomination process also allows ITS projects to be anchor projects. A key challenge to this new paradigm is how to identify these projects, and then support them throughout their development process, as SCCP funds are eligible for construction phase activities.

SB 1 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 instance, 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<sup>14</sup>. The Solutions for Congested Corridors Program (SCCP) guidelines were subsequently adopted on December 6, 2017.

Though Caltrans is the owner-operator of the SHS, the regions – especially in the urbanized areas of the state – play an important role in planning capital improvements on the SHS. That said, regions may have different priorities from Caltrans in terms of capital and operational improvements on the SHS. The Caltrans Districts, on the other hand, 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 on the SHS. As language in SB 1 clearly emphasizes, collaboration with partner agencies is critical. The Regional ITS Architecture process is a tool that both requires and encourages collaboration between agencies when done correctly. The completed Regional ITS Architectures around the state should be a rich repository of high priority ITS projects for the regions and the Caltrans Districts to develop.

Findings of the Caltrans Statewide Planning for Operations Strategic Work Plan conclude that Districts should develop lists of high-priority projects. Such lists should be compiled from either corridor studies or, where available, District ITS plans, as well as projects identified in regional plans that identify Caltrans as a stakeholder, and from guidance by 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 ITS

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<sup>14</sup> Interim State Highway Operation and Protection Program (SHOPP) Guidelines, California Transportation Commission, June 16, 2017, Section 25 (Eligibility), p. 8.



project lists developed at the regional level, preferably conducted in collaboration with partner agencies.

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 the Regional ITS Architectures, and that conversely, (b) the architectures reflect the proposed projects that are needed by the Districts or that include them as key partners.

### **3.2 State Transportation Improvement Program (STIP)**

ITS activities may be included within projects shown in the STIP. The STIP addresses projects that involve not only Caltrans operations and maintenance investments, but capacity improvements involving both Caltrans and other regional projects proposed for construction in a five-year time frame. The STIP programming process can be completed with the completion of the Project Study Report (PSR), defined improvement projects being nominated by an MPO/RTPA to be compiled into the Regional Transportation Improvement Program (RTIP) or by Caltrans to be included in the Interregional Transportation Improvement Program (ITIP). Both programming documents describe specific projects that will be constructed and/or operated over the next five years.

Both programming documents are then submitted to CTC and combined into the STIP. 75% of STIP funding comes from the RTIP, and 25% from the ITIP. The STIP is also a five-year programming document, and is updated every two years. Projects in the STIP are typically projects that increase the capacity or provide major improvements to the State Highway System (SHS).

While TSMO-related ITS projects are often programmed within the SHOPP (see below), it is critical to assure that ITS elements contained within the STIP are consistent with regional transportation plans, RITSA's and, as needed, the SWITSA. This is particularly important for multi-modal and other ITS projects that might normally not be part of the SHOPP due to a regional focus or coverage along non-SHS routes (although they may be contained within corridors that include state highways). ITS components contained within STIP projects should be priced both in terms of capital costs and operations and maintenance costs.

### **3.3 Statewide Highway Operations and Protection Program (SHOPP)**

Opportunities for funding ITS projects have increased thanks to SB 1, including the SHOPP and the Solutions for Congested Corridors programs. The following provides an overview of the State Highway Operation and Protection Program (SHOPP), the role of ITS within SHOPP, and how Caltrans District projects are incorporated into SHOPP. The project nomination process also allows ITS projects to be “anchor projects” consistent with District SHOPP targets (featuring identification of ITS elements or systems as “the anchor asset” as opposed to serving as a “satellite asset” as part



of other construction activities). But a key question is: how can these projects be identified and then supported throughout their development process?

### 3.3.1 The Role of ITS in SHOPP

SHOPP is the State’s “fix-it-first” program that funds the repair and preservation of the State Highway System (SHS), safety improvements, and some highway operational improvements. SHOPP is a four-year program of projects that addresses traffic safety, roadway rehabilitation, roadside rehabilitation, and operations related to the State Highway System. The SHS includes State owned roadways, highways and bridges (including associated bicycle and pedestrian infrastructure) and their supporting infrastructure such as culverts, intelligent transportation systems (ITS), roadside safety rest areas, and maintenance stations<sup>15</sup>.

State law requires Caltrans, in consultation with the CTC, to prepare a robust Transportation Asset Management Plan (TAMP) to guide selection of projects for the SHOPP. The TAMP is intended to be a performance-based plan that “adopt targets and performance measures reflecting state transportation goals and objectives.” Caltrans and the CTC use federal requirements established in both the Moving Ahead for Progress in the 21st Century (MAP-21) and the Fixing America’s Surface Transportation (FAST) Acts, respectively, to formulate what constitutes the TAMP. The CTC reviews and approves the TAMP and adopts targets and performance measures reflecting state transportation goals and objectives. In 2015, the CTC approved four asset classes for the TAMP that included: pavement, bridge, culverts, and Intelligent Transportation System (ITS) components.

The performance measure specifically established for the ITS asset class is as follows:

- The Legislature’s intent is that Caltrans meet the following preliminary performance outcome for additional state highway investments by the end of 2027, in accordance with applicable state and federal standards:
  - Not less than 90 percent of the transportation management system units in good condition<sup>16</sup>.

“Projects eligible for SHOPP funds include major capital improvements that are necessary to preserve and protect the state highway system. Projects included in the program shall be limited to improvements relative to the maintenance, safety, operation, and rehabilitation of state highways

<sup>15</sup> Proposed 2016 SHOPP, State Highway Operation and Protection Program Fiscal Years 2016-17 through 2019-20; Prepared by the California Department of Transportation; January 29, 2016

<sup>16</sup> Transportation Asset Management Plan Guidelines; California Transportation Commission; Revised June 29, 2017





and bridges that do not add a new traffic lane to the system...<sup>17</sup> Examples of ITS-oriented operation improvement projects include the following:

- Intersection modifications including traffic signals
- Traffic Management Systems including ramp metering
- Traffic Management Centers
- Multimodal corridor projects

Examples of other operational improvement projects that are not ITS-oriented are not shown here to maintain the ITS focus of this document.

### 3.3.2 Process for Connecting Regional and Statewide ITS Project Development Activities

Regions and Caltrans Districts should work in coordination to develop lists of high-priority ITS projects as a basis for coordinating with partners and project nominations. Sections 1 and 2 of this document address ITS planning and architecture-related activities that would result in these project nominations. The development process must 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. The proposed projects can be assessed using sketch planning tools such as the California Benefit Cost (Cal-B/C) model.

Long-term high-priority ITS project list should be updated using more detailed corridor plans, preferably conducted in collaboration with partner agencies.

Figure 9 provides an overview of a four-step process that links ITS project definitions (including regional definitions and Caltrans District ITS projects) to both regional and statewide ITS programs. 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.

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<sup>17</sup> Interim State Highway Operation and Protection Program Guidelines; California Transportation Commission; June 16, 2017

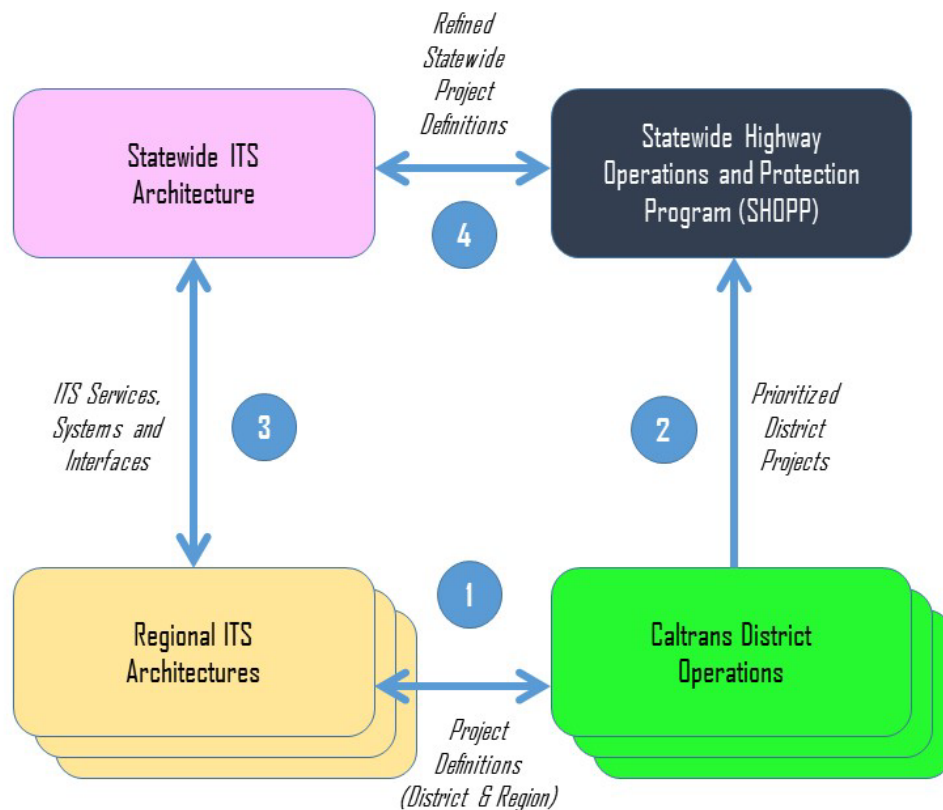


Figure 9. Statewide and Regional Project Development and ITS Architecture Coordination

The most significant priority in developing a statewide list of ITS projects (using SHOPP as the vehicle) is assuring that the regional architectures incorporate the Caltrans Districts in a key role. The “two-way” arrow reflects that any one of three processes as shown in Section 2 may yield project definitions, whether it is through initial RITSA development, initial RTP development, or coordinated development of both. Thus, projects may either be defined and developed prior to RITSA updates and thus 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 10. Doing this requires that Caltrans Districts and regional stakeholders collaborate on defining operational objectives, identifying operational and performance needs, establishing the needed ITS strategies and services, 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: (a) are system wide in nature, (b) focus on specific corridors (e.g., “Connected Corridors”), and (c) provide targeted improvements that may

include life-cycle-based upgrades to existing devices, or new components, communications or other elements incorporated within other larger, projects such as road reconstruction, widening, or Express Lane deployments. Projects developed in the (a) and (b) categories for the most part involve systems engineering analysis activities associated with new systems and software components. On the other hand, projects in category (c) may be expansion or in-kind replacement of existing technologies, and as such may not require a full systems engineering analysis.

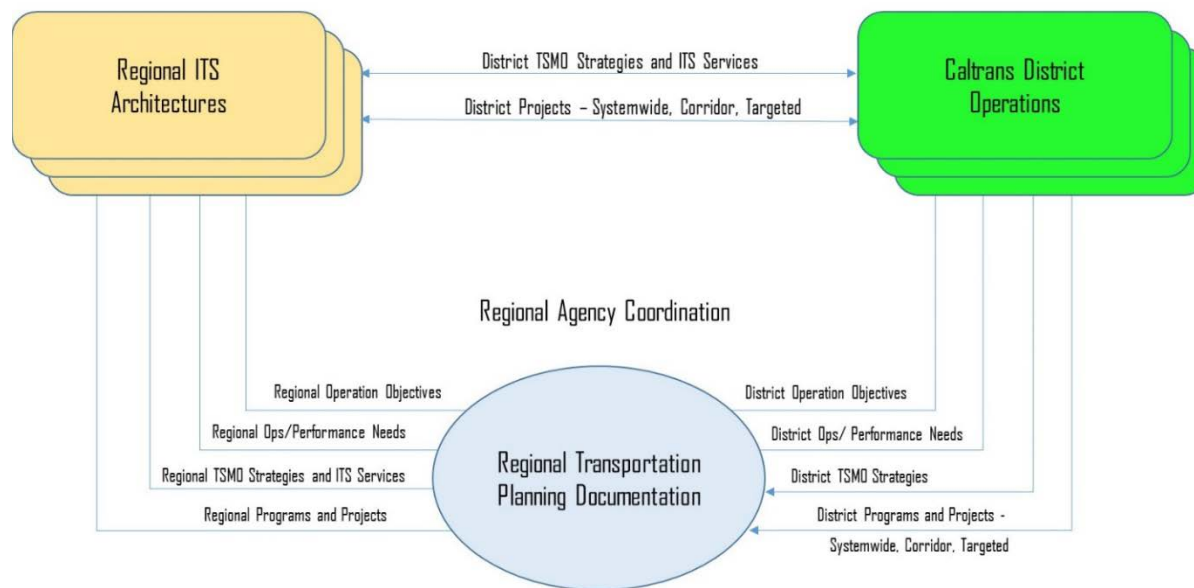


Figure 10. Step 1 - Caltrans District Project Definitions in Coordination with Regional ITS Architecture Activities

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 are then to be prioritized through the SHOPP development process and incorporated into a statewide ITS project prioritization under the umbrella of SHOPP as shown in Figure 11. 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.

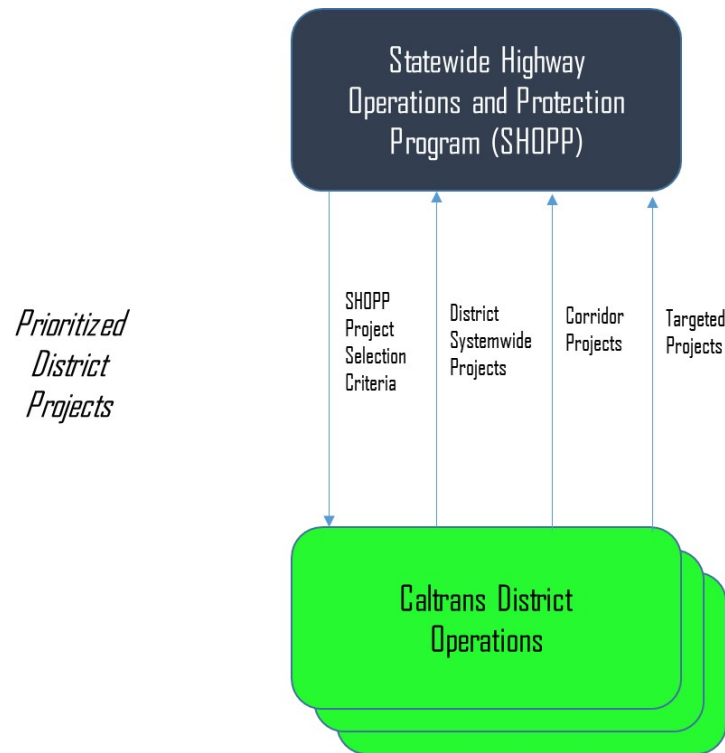


Figure 11. Step 2 – Incorporation of Prioritized District Projects into SHOPP Plan Based on Project Selection Criteria

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 10-year SHOPP plan as it evolves to incorporate operational improvement and ITS investments. Categorization of system wide, corridor or targeted activities as discussed above can 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 serves as the primary basis of ITS project activities reflected within statewide plans.

In Figure 12, 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: (a) defining gaps in services or other functions related to corridors not included within regional architectures, (b)

defining interfaces and information-sharing needs between regions, and (c) 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 builds on current statewide standardization activities related to electronic tolling and future road-pricing activities.

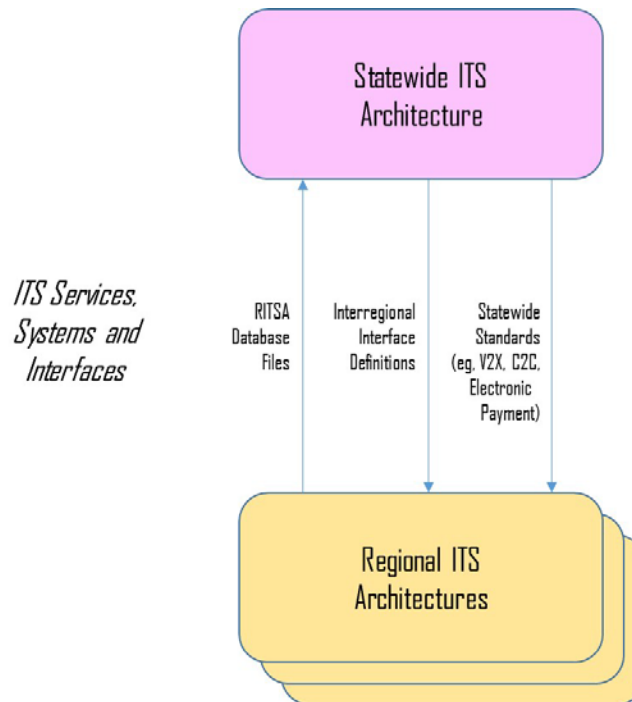


Figure 12. Step 3 – Relationship between Regional and Statewide ITS Architectures

In Figure 13, the Step 4 detail (coordination between SHOPP and SWITSA development) describes how SWITSA definitions and gap assessments may be used to further define statewide initiatives in the SHOPP. 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 be addressed.

Step 4 also includes top-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 corridor funding programs.

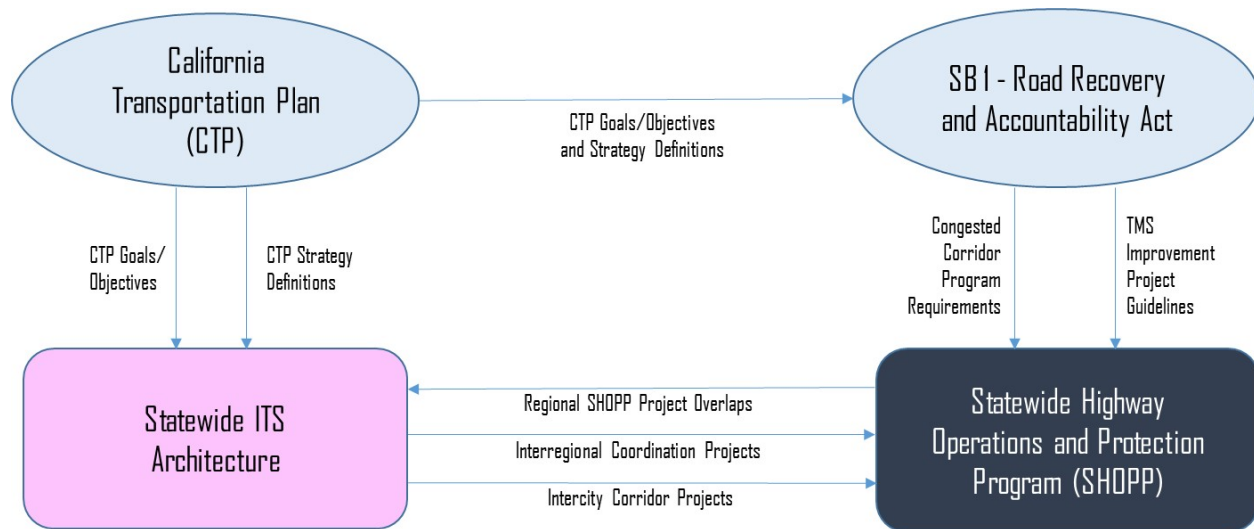


Figure 13. Step 4: Statewide ITS Architecture and SHOPP Coordination Driven by CTP and SB1 Guidance

The above concepts are consistent with all the Planning for Operations activities framework completed by Caltrans. Such a direction focuses ITS program and project development activities at the regional level, with the Caltrans District working in partnership with regional stakeholders. It is critical that each District provides a multi-year ITS Plan incorporated into RTPs and RITSAs, as well as into the statewide program and SHOPP. This has the effect of assuring consistency between statewide and regional efforts, and also assures both statewide and regional support for specific projects that benefit both the State Highway System and regional stakeholders.

### 3.3.3 Regional Transportation Planning Agency Coordination

The Self-Help Counties Coalition suggested to Caltrans that enhanced communication and coordination in the SHOPP program development process would be beneficial to the regions around the state. Specifically, the counties are interested in earlier information regarding what SHOPP projects are being proposed, programmed, and ultimately delivered. Caltrans developed three specific action steps to enhance earlier communications, covering planning, programming and delivery. These steps are in addition to statutory requirements that direct Caltrans to provide the draft SHOPP to transportation agencies for an opportunity to review and comment.

- Planning Process:** Caltrans will present the 10-year SHOPP Plan to the Regional Transportation Planning Agencies (RTPA) at an RTPA meeting so these stakeholders are aware of both the overall statewide needs and the estimated funding levels. Caltrans Districts will share their two-year Project Initiation Document (PID) work plan list of projects that will be candidates for the next SHOPP programming cycle. The planning process is an opportunity to coordinate proposed SHOPP projects with regionally-funded projects in order to synchronize timeframes, maximize benefits, and minimize impacts to the traveling public.



- **Programming Process:** In the summer of odd years, Caltrans will present information to RTPAs concerning the timing and framework for development of the upcoming SHOPP. Caltrans Districts should share with the regions which projects they will be submitting as candidate projects for the upcoming SHOPP. This is another opportunity to coordinate and confer with local partners to synchronize timeframes, maximize benefits and minimize impacts to the traveling public. The Caltrans Division of Transportation Programming will circulate the four-year program to the RTPAs for review and comment. In addition, the Caltrans Programming Division Chief will present the proposed four-year program at the RTPA meeting. Comments received will be incorporated into the final SHOPP programming document.
- **Status Updates:** Caltrans Districts will update the RTPAs on a quarterly or semi-annual basis on: (a) the list and status of PID projects being developed as well as, (b) the status of funded SHOPP projects currently in delivery. At a minimum Caltrans Districts will provide a summary-level status of project delivery on all currently programmed SHOPP projects semiannually<sup>18</sup>.

### 3.4 Federal Funding Opportunities

Federal Transportation Improvement Programs (FTIPs) for each region are federally mandated four-year programs of all surface transportation projects that will receive federal funding or are subject to a federally required action. The FTIP is a comprehensive listing of such transportation projects proposed over a six-year period in a region. Regional Metropolitan Planning Organizations (MPOs) are responsible for developing the FTIP for submittal to the California Department of Transportation (Caltrans) and the federal funding agencies.

The *Caltrans Local Assistance Program Guidelines* document (LPP 10-01, April 2010) is a detailed collection of instructions on how to use available federal funding for local transportation projects, including ITS. Chapter 13 of the Local Assistance Guidelines outlines how ITS projects, funded through Local Assistance, should conform to the FHWA and FTA Final Rules on ITS Architectures. As these Local Assistance projects trace through their initial project development steps, it is still important to assure that these projects map to the relevant RITSA systems and services and tie to specific operations objectives and performance measures defined as part of the transportation planning process, and/or contained within RCTO and ITS strategic plan documentation. Full lifecycle costs need to be included as well.

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<sup>18</sup> Proposed 2016 SHOPP, State Highway Operation and Protection Program Fiscal Years 2016-17 through 2019-20; Prepared by the California Department of Transportation; January 29, 2016



Under the Fixing America's Surface Transportation (FAST) Act of 2015, ITS and technology projects at the state or regional level may be funded through the following Federal initiatives<sup>19</sup>:

- **Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program.** Authorizes \$60 million in the years 2016-2020 to make competitive grants for the development of model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment. No project may be awarded more than \$12 million in a single year and the Federal share is up to 50% of the project costs. Eligible activities include:
  - Advanced traveler information systems;
  - Advanced transportation management technologies;
  - Infrastructure maintenance, monitoring, and condition assessment;
  - Advanced public transportation systems;
  - Transportation system performance data collection, analysis, and dissemination systems;
  - Advanced safety systems, including vehicle-to-vehicle and vehicle-to-infrastructure communications;
  - Technologies associated with autonomous vehicles, and other collision avoidance technologies, including systems using cellular technology;
  - Integration of intelligent transportation systems with the smart grid and other energy distribution and charging systems;
  - Electronic pricing and payment systems; or
  - Advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly and disabled individuals.
  
- **Intelligent Transportation Systems (ITS) Program.** Provides \$100 million annually for the research, development, and operational testing of Intelligent Transportation Systems (ITS) aimed at solving congestion and safety problems, improving operating efficiencies in transit and commercial vehicles, and reducing the environmental impact of growing travel demand. Guided by the required five-year ITS Strategic Plan, the program is currently focused on significantly reducing crashes through advanced safety systems based on interoperable wireless communications among surface transportation vehicles of all types, traffic signals, other infrastructure systems, pedestrians, wireless devices, and automated vehicle systems. A portion of this amount may be incorporated into the ATCMTD program (see above). The FAST Act adds to the ITS Program a new goal: enhancement of the national freight system and support to national freight policy goals, and requires research into cybersecurity to prevent hacking, spoofing and disruption of CAV operations. ITS funds used for specific operational tests:
  - They shall be used primarily for the development of ITS infrastructure, equipment, and systems; and

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<sup>19</sup> <https://www.fhwa.dot.gov/fastact/factsheets/>





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- To the maximum extent practicable, they shall not be used for the construction of physical surface transportation infrastructure unless the construction is incidental and critically necessary to the implementation of an ITS project.
- **Congestion Mitigation and Air Quality Improvement (CMAQ) Program.** Authorizes between \$2.3 and \$2.5 billion annually (2016-2020) to provide a flexible funding source to State and local governments for transportation projects and programs to help meet the requirements of the Clean Air Act. Funding is available to reduce congestion and improve air quality for areas that do not meet the National Ambient Air Quality Standards for ozone, carbon monoxide, or particulate matter (nonattainment areas) and for former nonattainment areas that are now in compliance (maintenance areas). 2% is set aside for State Planning and Research, while at least 25% provided to a given state is to be allocated to nonattainment or maintenance areas. The state may transfer up to 50% of CMAQ funds to other selected programs that will support congestion mitigation. Eligible activities include the following:
  - Transportation project or program that is likely to contribute to the attainment or maintenance of a national ambient air quality standard, with a high level of effectiveness in reducing air pollution, and that is included in the metropolitan planning organization's (MPO's) current transportation plan and transportation improvement program (TIP) or the current state transportation improvement program (STIP) in areas without an MPO.
  - Verified technologies for non-road vehicles and non-road engines that are used in port-related freight operations located in ozone, PM10, or PM2.5 nonattainment or maintenance areas
  - Installation of vehicle-to-infrastructure (V2I) communications equipment
  - Electric vehicle and natural gas vehicle infrastructure and adds priority for infrastructure located on key corridors
  - Truck and freight emissions reduction
- **Highway Research and Development.** Authorizes \$125 million annually in strategic investment in research addressing current and emerging highway transportation needs. A portion of this amount may be incorporated into the ATCMTD program (see above), and up to \$10 million may be set aside each year for Performance Management Data Support activities that support MPOs.
- **Highway Safety Improvement Program (HSIP).** Authorizes \$2.25 to \$2.407 billion annually between 2016 and 2020 to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned public roads and roads on tribal lands. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads that focuses on performance. Several ITS-related activities are eligible for funding, including installation of V2I equipment and pedestrian hybrid beacons, along with other unspecified activities. It prohibits the use of HSIP funds for automated traffic enforcement systems except in school zones.

- **Surface Transportation Block Grant (STBG) Program.** Provides \$11.1 to over \$12.1 billion annually to states apportioned as a lump sum based on apportionment percentages established by law. IN turn, the grant amounts within the state are to be apportioned to urban areas based on their relative share of population, as well as to smaller communities based on coordination with MPOs. Up to 5% may be used for border crossing infrastructure, and up to 50% of funds may also be transferred to other programs including CMAQ. In general the funds are to be spent on non-local roads and non-collectors, but may be used on bicycle and pedestrian projects.
- **Surface Transportation System Funding Alternatives Program.** Provides \$15 to 20 million annually to states for the demonstration of user-based alternative revenue mechanisms that utilize a user fee structure to maintain the long-term solvency of the Highway Trust Fund. In California, such funds are being used to demonstrate distance-based road pricing technologies. The program needs to address both the technology, interoperability, and potential user acceptance and equity concerns related to such programs.
- **Technology and Innovation Deployment Program.** Provides \$67.5 million annually to accelerate the implementation and delivery of new and beneficial innovations and technologies resulting from highway research and development. A portion of this amount may be incorporated into the ATCMTD program (see above), while at least \$12 million per year is to be set aside for pavement technology. Funds are apportioned to states, but some or all of a state's funds (at their request) may be used for "pooled-fund" initiatives benefitting several states. Program use for particular projects is limited to 80% of the project budget.



*Projects proposed for Federal funding should tie directly into SWITSA or RITSA services and ideally, into ITS programs and projects already defined within RCTOs or ITS Strategic Plans and incorporated within RTPs and/or statewide initiatives (e.g., SHOPP or STIP).*

### 3.5 Partnerships and Privatization

There are several areas in which the private sector has heavily influenced transportation services and activities in recent years:

- Autonomous vehicle development (most of which are electric powered)
- Shared mobility utilizing transportation network companies (i.e., mobile ride dispatching, car-sharing services, bike share)
- In-vehicle products and smartphone applications containing live maps, traffic data, transit information and advisories as well as generating probe data and crowd-sourced information



- Wireless communications using high-speed, location-specific data. For example, 5G wireless is being demonstrated along with Dedicated Short-Range Communications (DSRC) for targeted arterial operations corridors and various connected vehicle demonstrations

Not all of the above are driven by public sector policies or desires. In some cases, the private sector identified a market for such services, along with their potential for monetization and revenue, and is now developing that market. Through partnerships with some longtime vendors in the ITS world such as mapping and GPS companies, as well as automakers who offer their vehicles as mapping, communications and entertainment platforms, private sector entities have become important stakeholders not just at a national level but also for statewide and regional ITS applications.

It is acknowledged that private sector services and the goals of private sector providers do not always align with goals of the state or public agencies. For example, the travel demand impacts of transportation network companies (TNCs) such as Uber or Lyft are not fully known, and combined with the use of Connected and Autonomous Vehicles (CAVs), may actually increase traffic volumes even as vehicle electrification reduces GHG. Secondly, the data from TNCs may provide tremendously useful information for public agencies on real-time operations as well as planning data. However, TNCs, while they may be willing to share some of their data, may consider much of it proprietary to their operations.

Nevertheless, the mobility and information services that the private sector has provided without public investment have yielded numerous actual and perceived traveler benefits as well as choices. It is thus important to assure, within integrated transportation planning and ITS architecture activities, that the public sector in California can assure an attractive playing field for private sector services.

The advent of CAVs will introduce further technological complexity to ITS in the future. In-vehicle technologies are primarily developed by the automotive and electronics industries. Although there has been some engagement between original equipment manufacturers (OEMs) and AASHTO, the key tools within the vehicle to implement autonomous operation, as well as provide control and information functions that respond to external V2I and V2V input, are being done with limited input from the public sector. Nevertheless, AASHTO-OEM engagement is necessary so that tailored products and services offered by different manufacturers accommodate standardized CAV functions and services supporting public sector resources, e.g., traffic signals.

In short, statewide and regional architectures need to clearly document statewide and regional data hubs, CAV and other advanced applications, including functionality and standards. There will also need to be clearer definitions of private sector interfaces and roles as partners as CAV applications and deployments emerge. For example, by assuring that data sharing between public sector agencies and private sector information and CAV development and operations entities (e.g., “data portals”) are included within RITSAs and built into project activities, use of data exchange standards is critical. Such standards should be built into RITSAs, and assuring these are identical on a statewide



basis will be an important function of a SWITSA. One example of such an application is Virginia's Smarter Roads initiative where traffic signal timing and other pertinent operations data can be shared with private sector users for connected vehicle services. (Information is at [www.smarterroads.org](http://www.smarterroads.org)).

Development of partnerships can occur through definition of jointly-developed projects or private sector initiatives that rely on industry standards and do not utilize proprietary or turn-key interfaces. Caltrans or other agencies developing data portals are one example, but development of mobility projects utilizing standardized signal phase and timing (SPaT) data also provide opportunities to implement V2I, V2V and V2X communications, supporting improved real-time traffic management and operations. Likewise, other projects may utilize standardized Basic Safety Messages (BSM) from vehicles for safety warnings, real-time monitoring and data mining for operational trend assessments. These provide further opportunities to take advantage of private sector initiatives as well as industry standards. They would require definition of such standards, interfaces and services within a RITSA, and standardizing interfaces across the state using a SWITSA.

#### **4. Project Engineering and Development**

After a project is programmed, it enters a more thorough project engineering phase. Traditional transportation projects have a “straight line” approach to project engineering, referred to as the “design-bid-build” process, in which a project is designed, sent out to bid, and then built.

ITS projects involving new software and other functionality follow a process called Systems Engineering (SE) Analysis, developed by USDOT with substantial input from FHWA's California Division. SE begins by establishing a project need, based upon stakeholder input, existing transportation plans, and previous studies. Because the needs assessment is the foundation for SE, regional planning and ITS Architecture documents play a key role as building blocks for SE. SE employs an iterative process (feedback loops) of user needs analysis, concept of operations development, requirements analysis, architecture, design, testing, and evaluation.

It is noted that Caltrans ITS projects that are major capital projects (particularly involving physical components) still go through the traditional capital project development process. Even for a minor ITS project in the field, capital project engineering and standards can impact project delivery outcomes – for example the quality/safety design features of a pole – if there is more down time of an element due to durability or reliability.

The SE process works hand-in-hand with the Caltrans project development process. When new ITS system components are embedded in larger capital projects the SE process is coordinated with the traditional project development process for non-ITS elements. For those ITS projects consisting of the upgrade, expansion or replacement of elements that already exist and are reflected in the RITSA,

an extensive SE process is not necessary, but the Caltrans project development process should be followed.

With the advent of Agile development processes and Service-Oriented Architectures as discussed later in this section, SE activities nevertheless remain a critical means of measuring success and verifying that services are being provided effectively. Hence, definition of services and interfaces will continue to be of paramount importance, and thus the planning and RITSA processes will continue to provide an important input into defining systems that will need to be implemented for managing the transportation system.

## 4.1 Systems Engineering Processes



*System engineering is a planning process for technology projects that emphasizes lifecycle planning and upfront system definition. The process integrates all the disciplines and specialty groups into a team effort, forming a structured system development process from planning through design, development, testing, operations, maintenance and retirement of the asset.*

*While this Guide provides an overview of this process, more detailed information is available in the USDOT “Systems Engineering for Intelligent Transportation Systems” document as well as Chapter 13 of the Caltrans Local Assistance Program Guidelines (see References/Resources section).*

### 4.1.1 The Vee Diagram

The V-shaped diagram (“Vee”) in Figure 14 shows the relationship between SE to planning activities and RITSA. The iterative verification and validation steps are shown by the arrows going across the Vee. The purpose of these iterations is to assure the system’s integration and implementation is consistent with the initial needs and requirements development. This formalized planning and back checking minimizes risk by ensuring that the project the stakeholders agreed upon is actually implemented; the plans and requirements are detailed correctly; and, any problems are worked out before next steps are taken.

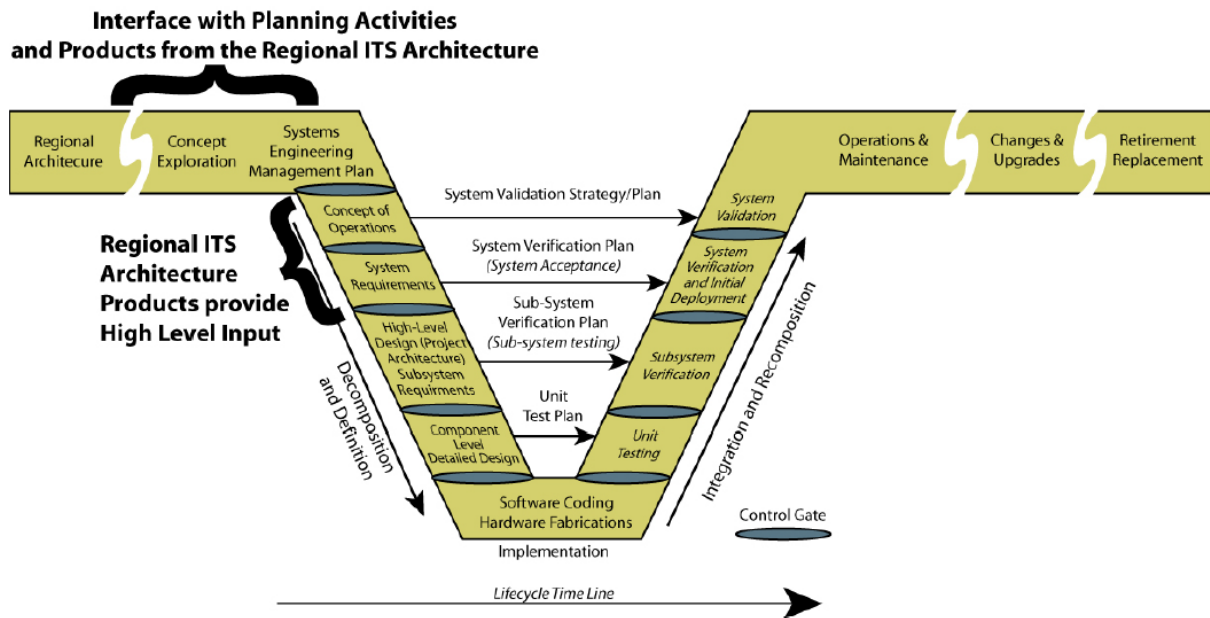


Figure 14. Systems Engineering Process and Inputs from Planning and RITSA Activities

Another important feature of SE is the alternatives analysis that takes place to select the most appropriate solution. Actual technology selection takes place after systems planning, thus the system is based on needs and requirements and not technology solutions. This ensures the most appropriate technology is selected and that the operational requirements are fully developed.

The “Vee” SE diagram is again presented in Figure 15, this time highlighting corresponding elements for traditional “straight line” project planning. The horizontal arrows in the middle of the Vee represent System Engineering’s distinguishing verification and testing procedures.

The FHWA report “Systems Engineering for Intelligent Transportation Systems” demonstrates the integration of ITS project development and capital project development by drawing parallels between the two processes.<sup>20</sup> Parallels exist throughout the two. This report is important reading to understand the impact that SE will have on business processes where technology is integrated into traditional transportation projects.

<sup>20</sup> *Systems Engineering for Intelligent Transportation Systems: An Introduction for Transportation Professionals*, FHWA-HOP-07-069, USDOT, January 2007.

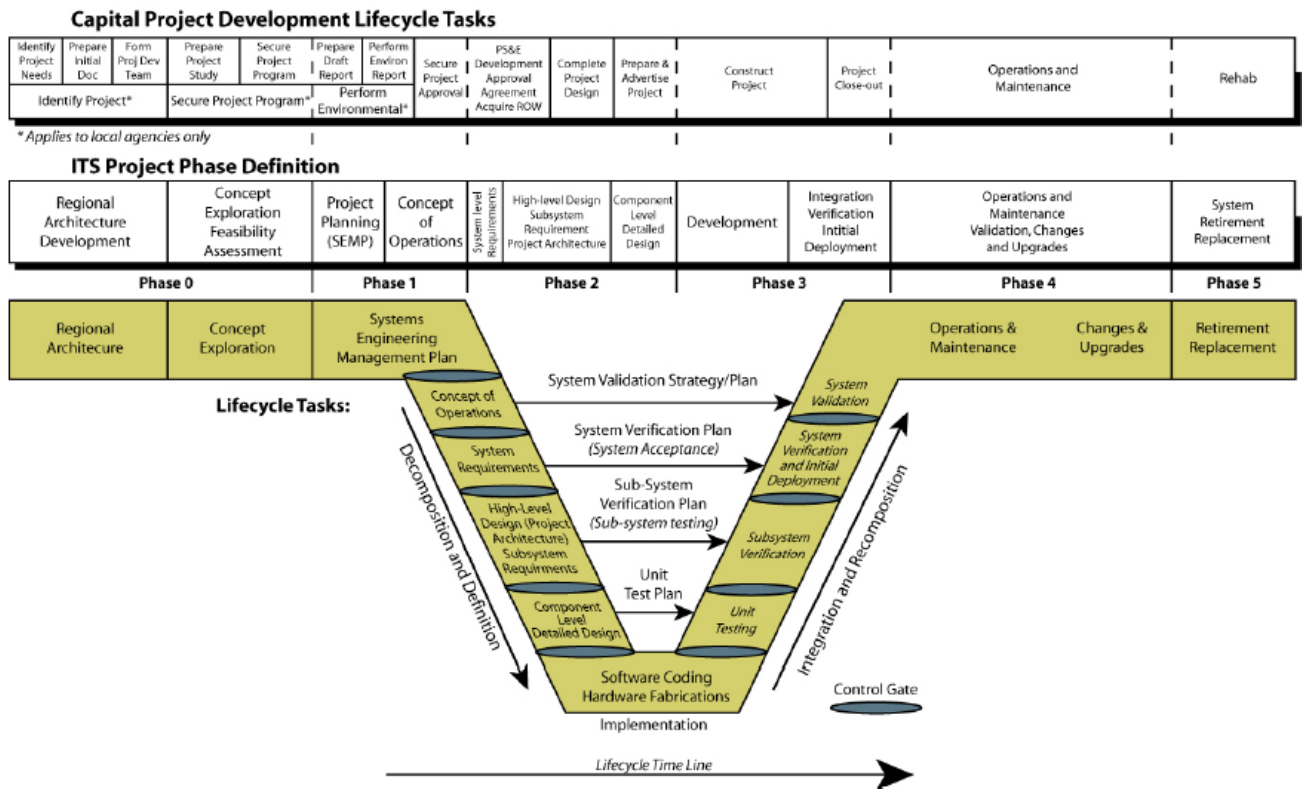


Figure 1. Correlation of SE Process to Capital Project Development Activities

Project financing undergoes some modifications when ITS becomes part of a project budget. The “Phase 0” of both ITS and capital project development includes an alternatives analysis and some preliminary cost analysis. Integrating capital project development into “Phase 1” of the Systems Engineering process requires participation of capital project planning and engineering members in the concept of operations development. The penetration of planning considerations is an unusual addition of the Systems Engineering process. With the Systems Engineering process, planning continues until the integration stage and into the design to ensure that all the components in a complex system can work together seamlessly throughout the system’s lifecycle. Spending more time and resources on the planning function minimizes costly risks by avoiding redesign during construction and implementation, a common pitfall for complex technology projects.

Major ITS projects focusing on larger scale ITS systems integration (e.g., interregional, interjurisdictional, inter-agency), require formal documentation called a Systems Engineering Management Plan (SEMP) as well as a companion Systems Engineering Review Form (SERF). The FHWA currently reviews and approves them.

Other less extensive or less complex projects with ITS components need to document a shorter list of items:

- The portions of the Regional ITS Architecture being implemented;
- Participating agencies and their roles and responsibilities;
- Alternative system and technology options;
- Applicable standards and testing procedures; and
- Resources for operation and management.



**The Systems Engineering Management Plan** is a project control document that identifies items to be developed, delivered, integrated, installed, verified, and supported. It also identifies the timing, roles and responsibilities, and technical processes of these tasks.

**Systems Engineering Review Form (SERF)** is a document required by FHWA to review and give adequate guidance for preparation of an acceptable SEMP. On a SERF, the submitting agency must provide as much as possible information for ITS requirements, and include a commitment to address them in detail during system design.

#### 4.1.2 Agile Processes and Service-Based Models

The SE process does not generate ‘one-size-fits all’ solutions. When applying the SE process to transportation projects, the number of steps and the level of effort applied to the process should be commensurate with the project’s ITS components’ scope and complexity. The complexity of the software, the number of changes required for the system, the budget, and the number of stakeholders are all factors to be taken into account when tailoring the SE process.

For example, the IT industry in general has been increasingly utilizing “Agile” development processes to create software applications that address customer needs. Agile development (also sometimes called “evolutionary project management”) involves incremental and iterative development activities that involve a team of software developers and the “customer” (e.g., public agencies and stakeholders). Frequently this is known as “scrum-based development”, based on the premise that not all requirements are defined at the beginning of a system development process, and by iterative system developments, requirements can be further defined and a system can be more quickly implemented. Agile development efforts are more difficult to document than more structured systems engineering efforts, but are becoming common for private-sector development activities. Nevertheless, constraints are needed in order to assure that minimum services and standard interfaces for tie-in to other systems are provided as defined within a RITSA.





Another consideration is that many of the newest ITS activities are relying on service-oriented-architecture (SOA) models, including “Software-as-a-Service” (SaaS) and “Mobility-as-a-Service” (MaaS). Such models can save money and reduce liability for public agencies through reducing the operations and maintenance staffs and physical facilities needed. SOA implications on technology selection are further discussed in Section 4.3 below.

#### 4.2 SET-IT Tool

The Systems Engineering Tool for Intelligent Transportation (SET-IT) provides a single software tool that integrates drawing and database tools with ARC-IT so that users can develop project architectures for pilots, test beds and early deployments. SET-IT utilizes Visio 2016 as its drawing and graphical interface tool and Microsoft Access for underlying data definitions. Computers must be equipped with Visio in order to use SET-IT’s capabilities.

The SET-IT framework includes physical, functional, enterprise, and communications views for a wide range of ITS and connected vehicle applications, including Safety, Mobility, Environmental applications as well as supporting services, including importing projects defined in the RAD-IT output for a RITSA. Physical object elements and flows descriptions may be further detailed.

SET-IT includes the ability to create a Concept of Operations (ConOps) document using either an IEEE Standard 1362 template or a template used in connected vehicle research projects, giving users the ability to modify the template as well as generate content from the diagrams and tables from the physical and enterprise views of the architecture. The Concept of Operations document describes the current state of operations, establishes the reasons for change, and defines operations for the future in terms of functions/features and supporting operations. For connected vehicle projects a ConOps establishes the driving needs for the project, shows the high-level physical and enterprise architecture view in both diagrams and definitions based on ARC-IT, and a set of operational scenarios.

SET-IT also imports the Needs and Requirements provided in RAD-IT for the Service Packages (application), which can be further detailed. Scenarios for a Service Package and sequences for operation may be included as part of the ConOps. Layered sets of communications protocols may be detailed as part of the physical architecture. Tabular outputs map specific architecture data flows and objects to each operational sequence of activities, allowing for a definition of how the different system elements will interact. Scenarios can also include security credentials and other details as needed.

#### 4.3 Technology Selection and Procurement Options

From the standpoint of typical ITS procurements using design-bid-build processes, it is generally recognized that ITS technologies often have a shorter lifecycle because of continuous technology



updating. Thus it is important to coordinate the schedules between the technology component implementation and the traditional construction to avoid technology obsolescence.

Technology selection for elements must be timed appropriately to avoid obsolescence. The level of detail of the system description increases during the SE process, but technology applications (including a range of alternatives) are given comprehensive consideration during every step of the planning process. However, as shown in the Vee model, technology selection actually happens at the last step of design phases (the left arm of the Vee), the component-level design/detailed design. When possible, technology selection should be pushed as close to implementation as possible. For example, when designing arterial intersections for new land development projects that will take three years to construct, the selection and purchase of traffic signal control software must be made at the end of the project so that the software will not be obsolete before implementation.

Design-Build, turnkey and public-private partnership activities introduce some constraints, particularly if the bid assumes a particular product or service provided by the partner, or if, for example, in the case of express lane projects, the toll system operational and technological components are defined in order to achieve compatibility within the state, i.e., California's FasTrak toll system and related technologies.

SOA models as discussed briefly in Section 4.1 (including SaaS and MaaS) require a definition of the services and interfaces needed (and hence benefit greatly from the definition of RITSAs), as well as specific performance requirements. But they rely on service providers (e.g., contracted services) to deliver the specific support activities rather than on agency-owned software and hardware platforms, and in some cases may use cloud-based platforms for activities such as performance analytics, traveler information, and data portal interfaces between agency data and CAV service providers.

SaaS might include, for example, freeway operations, signal timing, TMC staffing, and/or network asset management systems, traveler information systems, freeway service patrol operations, incident management and clearance activities, and procurement of probe, video and sensor data from third parties. MaaS activities may also include everything from contracted transit operations to bike sharing and vehicle-sharing services. However, these differ from shared mobility activities carried out independently by the private sector in that they must subscribe to performance requirements (including interfaces and information needs) defined by the public agency who is contracting these services.

These above activities do not discount the need for defining system requirements or developing ITS programs or architectures, but they do provide a different means of delivery that reduce the need to specify equipment or facilities within the physical public agency.



If specific products or services are included as part of a partnership project, it is important that interfaces follow specific open, industry-standard definitions and address the functionality requirements as defined at a high level, whether for the state or the region.

## 5. References

Numerous references, detailed documentation and websites were consulted in development of this document, and are readily available online to provide further guidance and instruction to Caltrans, MPOs and local agencies on the planning of ITS programs and projects to support TSMO activities and multi-modal services. These references, documents and websites are listed below. However, the products and documents evolve over time, so it is important to follow USDOT and Caltrans program activities to assure that the most current processes and program information are addressed in the ITS planning process.

**California Transportation Plan 2040: Integrating California's Transportation Future.** The California Transportation Plan (CTP) provides a long-range policy framework to meet future mobility needs and reduce greenhouse gas emissions. The CTP defines goals, performance-based policies, and strategies to achieve the collective vision for California's future statewide, integrated, multimodal transportation system. The plan envisions a sustainable system that improves mobility and enhances quality of life. California Department of Transportation, June 2016.

<http://www.dot.ca.gov/hq/tpp/californiatransportationplan2040/>

**Caltrans Strategic Management Plan (2015-2020)** is a roadmap of Caltrans' role, expectations, and operations. The tools used to implement this Plan are performance management, transparency, accountability, sustainability, and innovation. The Plan serves a number of functions: provide clear direction for meeting statewide objectives, create and deepen strategic partnerships, and provide performance measures that monitor success. California Department of Transportation, March 2015.

<http://www.dot.ca.gov/perf/>

**Planning for Operations and Intelligent Transportation Systems Website (Caltrans).** Planning for Operations is a concept meant to promote multimodal planning that supports transportation system management and operation (TSMO). System management strategies typically have high benefit/cost ratios and help Caltrans achieve its goals of system performance, stewardship, safety and operational efficiency. New and evolving federal and State policies direct Caltrans to improve its system management planning practices as a basis for performance-based decision-making. ITS planning and deployment is an important component of Planning for Operations activities. Latest version. <http://www.dot.ca.gov/hq/tpp/offices/omsp/poits.htm>



**Senate Bill 1 Website (California Transportation Commission).** Senate Bill 1, the Road Repair and Accountability Act of 2017, was signed into law on April 28, 2017. This legislative package invests \$54 billion over the next decade to fix roads, freeways and bridges in communities across California and puts more dollars toward transit and safety. These funds will be split equally between state and local investments. The website describes where the money is being allocated, including congestion relief, trade corridor, transit/rail, and non-motorized travel. Latest version. <http://rebuildingca.ca.gov/>

**Architecture Reference for Connected and Intelligent Transportation (ARC-IT).** Includes Regional Architecture Development for Intelligent Transportation (RAD-IT) tool and Systems Engineering Tool for Intelligent Transportation (SET-IT), USDOT, Federal Highway Administration, latest version. <http://www.arc-it.net>

**Applying a Regional ITS Architecture to Support Planning for Operations: A Primer,** introduces the key concepts of planning for operations and regional ITS architectures and then describes how the regional ITS architecture can be used to improve planning for operations. USDOT, Federal Highway Administration, FHWA-HOP-12-001, February 2012. <https://ops.fhwa.dot.gov/publications/fhwahop12001/index.htm>

**Regional Concept for Transportation Operations (USDOT-FHWA website).** Contains links to two FHWA documents that address a framework for developing operational strategies to address particular regional goals and objectives. [https://ops.fhwa.dot.gov/plan4ops/focus\\_areas/trans\\_ops.htm](https://ops.fhwa.dot.gov/plan4ops/focus_areas/trans_ops.htm)

**The Regional Concept for Transportation Operations: A Practitioner's Guide** is a collection of the observed successes and lessons learned from four metropolitan regions as they developed Regional Concepts for Transportation Operations (RCTOs), a management tool used by planners and operations practitioners to define a strategic direction for improving regional transportation management and operations in a collaborative manner. This guide offers lessons that can help other implementing regions to select the methods that are most effective in improving regional transportation system performance. FHWA-HOP-11-032, July 2011. <https://ops.fhwa.dot.gov/publications/fhwahop11032/>

**Regional Concept for Transportation Operations: The Blueprint for Action - A Primer,** introduces transportation operators and planners to the Regional Concept for Transportation Operations (RCTO), a document providing a framework that guides collaborative efforts to improve system performance through management and operations strategies. The primer describes the RCTO and its essential components, explain its potential role in the transportation planning process, and illustrates its development through examples. Additionally, the primer shows benefits gained from partnerships that develop an



RCTO and the keys for success as partners work toward an RCTO. FHWA-HOP-07-122, June 2007. <https://ops.fhwa.dot.gov/publications/rctoprimer/index.htm>

**State Highway Operations and Protection Program (SHOPP) and Minor Project Website (Caltrans).**

The Office of State Highway Operations and Protection Program (SHOPP) Management has primary responsibility for planning, developing, managing and reporting the four-year SHOPP portfolio of projects. This includes preparation of the four-year program, participating in the development of the State Highway System Management Plan, coordinating the formal amendment of adopted SHOPP projects, coordinating with CTC staff, management of the annual Minor Program, coordination with Districts and Headquarters divisions, and upkeep of project information in the Department's CTIPS database. (Latest Version) <http://www.dot.ca.gov/hq/transprog/shopp.htm>

**State Transportation Improvement Program (STIP) Website (California Transportation Commission).** Biennial five-year plan adopted by the CTC for future allocations of certain state transportation funds for state highway improvements, intercity rail, and regional highway and transit improvements.

<http://www.catc.ca.gov/programs/stip/>

**Office of Capital Improvement Programming Website.** Addressing STIP, Interregional Transportation Improvement Program (ITIP) and the Regional Transportation Improvement Program (RTIP). OCIP also develops the biennial ITIP, as outlined in the Interregional Transportation Strategic Plan (ITSP).

<http://www.dot.ca.gov/hq/transprog/ocip.htm>

**Federal Transportation Improvement Program (example).** Southern California Association of Governments (SCAG). The FTIP for the SCAG region is developed in partnership between the six County Transportation Commissions (CTCs) of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and Ventura as well as Caltrans Districts 7, 8, 11, 12 and Headquarters. This listing identifies specific funding sources and fund amounts for each project. It is prioritized to implement the region's overall strategy for providing mobility and improving both the efficiency and safety of the transportation system, while supporting efforts to attain federal and state air quality standards for the region by reducing transportation related air pollution. Projects in the FTIP include highway improvements, transit, rail and bus facilities, high occupancy vehicle (HOV) lanes, high occupancy toll (HOT) lanes, signal synchronization, intersection improvements, freeway ramps, non-motorized projects, bicycle and pedestrian. <http://ftip.scag.ca.gov/Pages/default.aspx>

**Caltrans Local Assistance Program Guidelines** document (latest) is a detailed collection of instructions on how to use available federal funding for local transportation projects, including ITS.



## Statewide ITS Architecture Assessment and Support Caltrans Planning for ITS Guide: 2018 Edition

Chapter 13 of the Local Assistance Guidelines outlines how ITS projects, funded through Local Assistance, should be developed to conform to the FHWA and FTA Final Rules on ITS Architectures.

<http://www.dot.ca.gov/hq/LocalPrograms/lam/lapg.htm>

<http://dot.ca.gov/hq/LocalPrograms/ITS/ITS.htm>

**California Transportation Asset Management Plan (TAMP)** allows California to maximize results by managing the lifecycle of transportation assets strategically to minimize costs and manage risks. It provides a framework for understanding performance gaps, prioritizing actions to address the gaps, and establishing business processes that streamline asset management activities. The TAMP meet both federal and state legislative requirements. January 2018.

[http://www.dot.ca.gov/assetmgmt/tam\\_plan1.html](http://www.dot.ca.gov/assetmgmt/tam_plan1.html)

**Systems Engineering Guidebook for Intelligent Transportation Systems, Version 3.0** provides a step-by-step description of ITS project life cycle activities, and serves as a resource and learning tool on the application of Systems Engineering Analyses (SEAs) for ITS projects. While it is not formal guidance for SEAs as required through 23 CFR 940.11, it provides a primer on systems engineering basics as needed for SEAs. This version was developed jointly by FHWA and Caltrans. The HTML version presents the document using eight different views (processes, deliverables, checklist, examples, roles, documents, capabilities, and PDF download version). <https://www.fhwa.dot.gov/cadiv/segb/> (Updated November 22, 2009)