Statewide ITS Architecture Assessment and Support

White Paper:
The Business Case for Statewide and Regional ITS Architecture Activities

Caltrans®

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Statewide ITS Architecture Assessment and Support

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Contents

1. Introduction 1
   1.1 Project Overview 1
   1.2 Purpose of this Document 1
   1.3 Organization of this Document 2
2. The Value of ITS Architecture Activities 2
   2.1 Validation of Opportunities as discussed by the Stakeholders 3
      2.1.1 Providing Examples, Best Practices, and Detailed Guidance to RITSA Owners and Users 3
      2.1.2 Improvement of Planning Procedures 6
      2.1.3 Use of RITSAs as a Tool to Incorporate Connected and Automated Vehicle (CAV) and Connected Corridor Activities into Regional Planning 8
      2.1.4 Enhancement of Staffing and Resources to Develop, Use and Maintain RITSAs 10
   2.2 RITSA/SWITSA Benefits for Project Deployment Activities 11
   2.3 RITSA/SWITSA Benefits for Coordinating Activities Across the State 12
   2.4 What Efforts are Needed to Achieve Benefits Using SWITSA and RITSA? 13
   2.5 Preparing for the Future – CAV 13
      2.5.1 How Will ITS Architecture Change? 14
      2.5.2 How Will Today's ITS Environment be Impacted by CAV? 16
      2.5.3 When Will All This Happen? 17
3. Potential Caltrans Initiatives 18
   3.1 Headquarters Initiatives 18
      3.1.1 Education and Support of Caltrans Management on the Value of RITSAs 18
      3.1.2 Changes to ITS Planning Procedures that Map RITSAs to Transportation Goals and Objectives, Including Operations-Oriented Activities 19
      3.1.3 Path for Migration of RITSAs to Expanded National ITS Architectures Involving Connected Vehicle Implementation Elements 19
      3.1.4 Internal and External Outreach on the Use and Enhancement of ITS System Builder .. 20
   3.2 At District Level 20
      3.2.1 Education and Support of Caltrans District Directors and Division Chiefs on the Value of RITSAs 20

3.2.2 Caltrans District Planning Coordination with MPOs and Other Agencies on RITSA Development 21
3.2.3 Developing or Participating in a RITSA Partnership for the Region 22
4. Summary and Next Steps 22
4.1 Updates to National ITS Architecture 22
4.2 Updated Caltrans ITS Planning Guidance 23

1. Introduction

1.1 Project Overview

The *Statewide ITS Architecture Assessment and Support* project provided technical assistance to Caltrans in assessing compliance of the Statewide and Regional Intelligent Transportation Systems (ITS) Architectures with federal requirements and the current state of the practice. Secondly, it assessed how the architectures are used in support of transportation planning activities and project development. For both of the above, the Project Team identified those areas where the architectures are in compliance and are being used as intended, as well as those areas where architectures are non-compliant, are not being maintained, or are not being used for integrated planning and project development. The primary outcome of this effort is updated guidance on the use of ITS architectures as part of transportation planning and project development activities.

1.2 Purpose of this Document

The Business Case for development, update and maintenance of the SWITSA and RITSAs defines the value that would exist to statewide and regional stakeholders in having the architecture as a useful tool to define ITS activities, functional and integration requirements, taking into consideration emerging activities such as Connected Corridors development and applications associated with Connected and Automated Vehicles (CAVs).

The findings in this White Paper are based on the comments and reactions received in the project's second Stakeholder Advisory Committee (SAC) workshop held in February 2017 in Los Angeles, hosted by the Los Angeles County Metropolitan Transportation Authority (LA Metro). Addressed in the workshop were barriers to use of RITSAs and the SWITSA along with opportunities to use them as a tool to (a) assist in the transportation planning process as it relates to Transportation System Management and Operations (TSMO), and (b) assist in development of particular ITS projects and programs. The workshop included the presentation of the results documented in Section 1 and 2 of this White Paper along with recommendations presented in Section 3.

The stakeholder responsiveness to the work completed on this study is invaluable. At the same time, of key importance is that the target audience of this study, while taking into primary consideration the regional stakeholders, is ultimately Caltrans. Thus, the actions that result from the Business Case definition should include identifying the role of Caltrans in assisting regions to develop, update and maintain RITSAs. As a result, this White Paper provides the following:

- Assessment of key ways that Caltrans can work, both within the Department and in engaging with MPOs in development of ITS architectures as a basis for planning and deployment of TSMO related projects

- Justification to MPOs and architecture owners for use, maintenance and updating
- Basis for direction on statewide ITS planning guidance and training supporting RITSA development

1.3 Organization of this Document

This White Paper is separated into the following sections:

- Establishing the Value of ITS Architecture Activities for Caltrans and Regional Stakeholders
- Identification of Caltrans Initiatives to Support Statewide and Regional ITS Architecture Development

2. The Value of ITS Architecture Activities

The Business Case for developing, maintaining and updating ITS Architectures, based on the Team;s prior assessment of barriers and opportunities to architecture development, plus further discussions by the SAC, should include the following:

- Cost and time savings to regional and local stakeholders, as well as Caltrans, for definition, development and implementation of transportation technology projects that involve multiple stakeholders, interagency information flows and coordination of operational activities.
- Ability to incorporate and utilize new and emerging technologies as part of architecture updates, taking into consideration current and emerging industry communications and functional standards needed on a statewide level, particularly with Connected and Automated Vehicles (CAVs), Connected Corridors, statewide electronic tolling and managed lanes, distance-based road pricing, and other initiatives requiring both statewide and nationwide standards.

To achieve the above, investments are needed as follows:

- Agency budget and staffing commitments for developing, maintaining and updating a RITSA. Justifications for doing this should be based on success stories as well as, conversely, what has happened when architectures have not been maintained or updated.
- Providing additional training of staff and making organizational improvements that are supportive of the RITSA life cycle. Justifications for doing this should include examples of benefits associated with investing in staff training and organizational enhancements.
- Training of ITS professionals as well as planners and non-technology-based personnel on the new national architecture reference, ARC-IT, which heavily incorporates CAV applications and

is accompanied by newer and richer development tools leveraging from the current Turbo Architecture applications, including the Regional Architecture Development for Intelligent Transportation (RAD-IT) tool. The Systems Engineering Tool for Intelligent Transportation (SET-IT) will enable further development of project-oriented architectures, concepts of operation, and requirements.

Recent investments in the Caltrans ITS System Builder tool could be leveraged as part of the required investments above. As such, the ITS System Builder tool and its role should be addressed as part of the Business Case presented in this White Paper.

2.1 Validation of Opportunities as discussed by the Stakeholders

Opportunities identified by RITSA stakeholders based on prior survey activities may be separated into 4 general areas:

- Providing Examples, Best Practices and Detailed Guidance to RITSA Owners and Users
- Improvement of Planning Procedures
- Use of RITSAs as a Tool to Incorporate Connected and Automated Vehicle (CAV) and Connected Corridor Activities into Regional Planning
- Enhancing of Staffing and Resources to Develop, Use and Maintain RITSAs

Each of these is discussed and validated below based on follow-up discussions by the SAC.

2.1.1 Providing Examples, Best Practices, and Detailed Guidance to RITSA Owners and Users

The key measure here is demonstrating that (a) cost savings and (b) time savings occur by developing an up-to-date ITS architecture that accurate reflects existing investments and institutional interfaces, and that providing improved training and guidance will support the architecture development resources and staffs that can support architecture development, updates and other maintenance activities.

The experiences presented by the I-210 Connected Corridors project, as presented by Joe Butler (California PATH), are instructive in identifying the issues associated with a RITSA that is not updated, and how having an updated RITSA might have benefitted the project. These experiences are summarized below:

- While an existing architecture did reflect a number of functions, components and interfaces that exist today among the regional stakeholders, other functions, components and interfaces reflected in the architecture had not been deployed, while still other functions, components and interfaces had been deployed but not reflected in the architecture, due to the limited updates and support to the RITSA over the past decade.

- As a result, both project funding and substantial time was spent trying to establish consensus and cooperation between agencies, as well as documenting elements that could be incorporated into the project but had not previously documented as part of the RITSA.

- Because many elements needed to be implemented that were reflected in the architecture but had not been actually deployed, additional time was needed to review existing conditions, which impacted timely decision-making, and scaled back what could be delivered in the short term ("Phase 1").

- A process was not in place for updating or incorporating the project within the RITSA. Because other updates were also needed, it would have been a substantial effort to perform a RITSA update within the Connected Corridors project, which was also outside the scope of the work effort. Instead a Project ITS Architecture following the National ITS Architecture paradigm was developed in order to reflect the more specific functional and physical components being proposed for the I-210 Connected Corridor.

The key benefits which would be provided by RITSA development along with consistent maintenance, support and updating activities, would thus include the savings of cost and time as follows:

- Reducing effort needed to obtain an inventory of existing systems and relationships

- Understanding where existing activities could be leveraged so redundant systems and technologies would not be required

- By having a dedicated system architect or architecture group within the owning agency, the region would have the ability to oversee the whole life cycle of the project and how it fits within the RITSA, rather than create a separate architecture that would be incorporated later.

- RITSA development and support would create an inventory of common interfaces and components that could be shared across a region for multiple instantiations of Connected Corridors or similar projects, as well as projects and functions that cross regional boundaries or are maintained on a statewide basis.

Figures 1 and 2 (from PATH) describes the ITS architecture process in terms of its ideal impact on project development (when it is updated and maintained properly, as shown in Figure 1), as well as its impact when updates and maintenance do not regularly occur (see Figure 2).

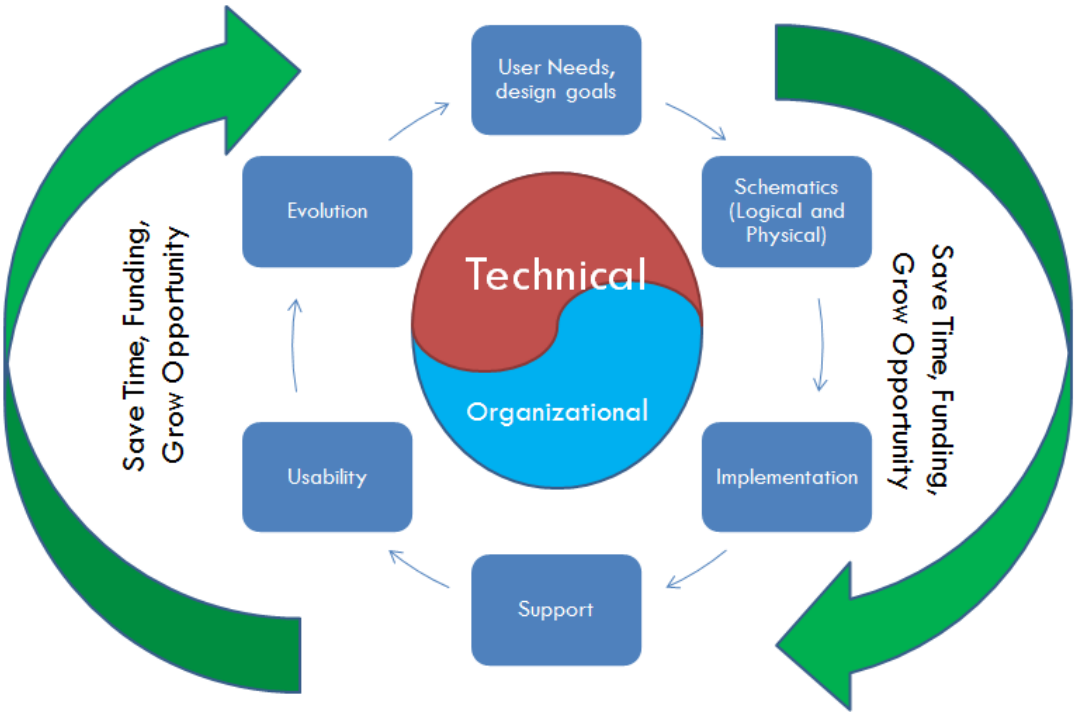

Figure 1: Impact of Proper RITSA Development, Maintenance and Update Activities on Project Development (California PATH)

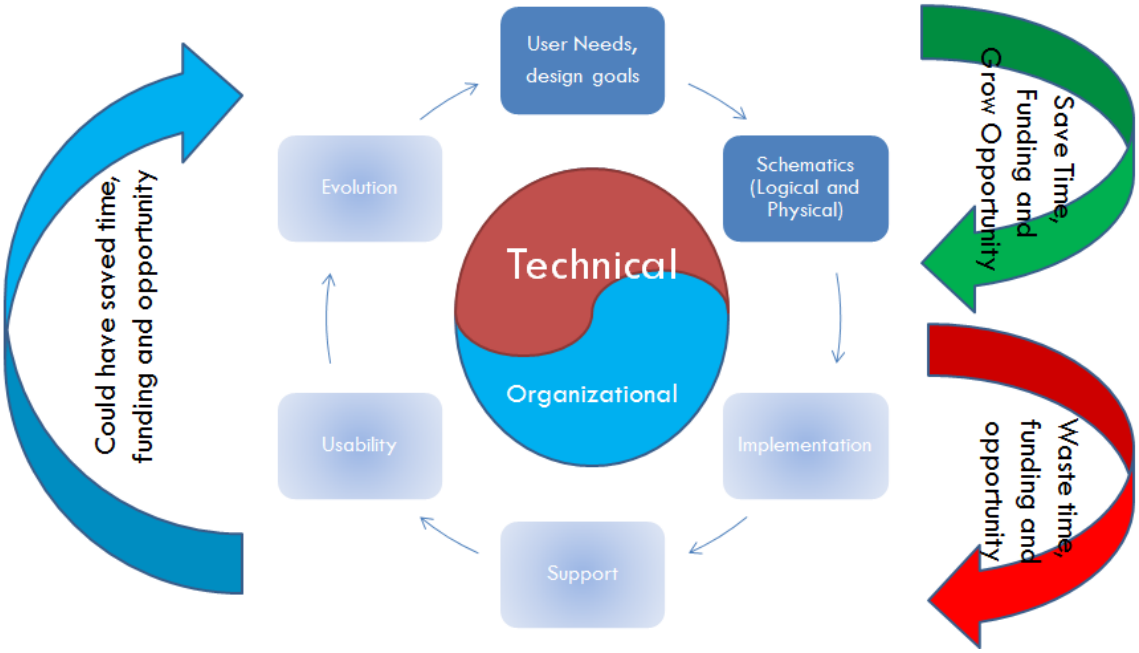

Figure 2: Impact of RITSA Use When Not Properly Maintained and Updated on Project Development (California PATH)

2.1.2 Improvement of Planning Procedures

Likewise, ITS architecture update efforts, when tied closely to ITS strategic planning activities, *assist in the ability to obtain Federal funding for particular project initiatives*. Examples include the St. Louis Regional ITS Architecture Update, which was done concurrently with a regional ITS plan update, and thus the architecture contained and documented regional activities for information sharing between public agencies, first responders, and traveler information providers that are eligible for or have received Federal funding. Figure 3 provides a framework for how Regional Architecture and ITS Strategic Plans may be correlated; notably, through definition of specific projects within the architecture, including pertinent elements, functions and information flows.

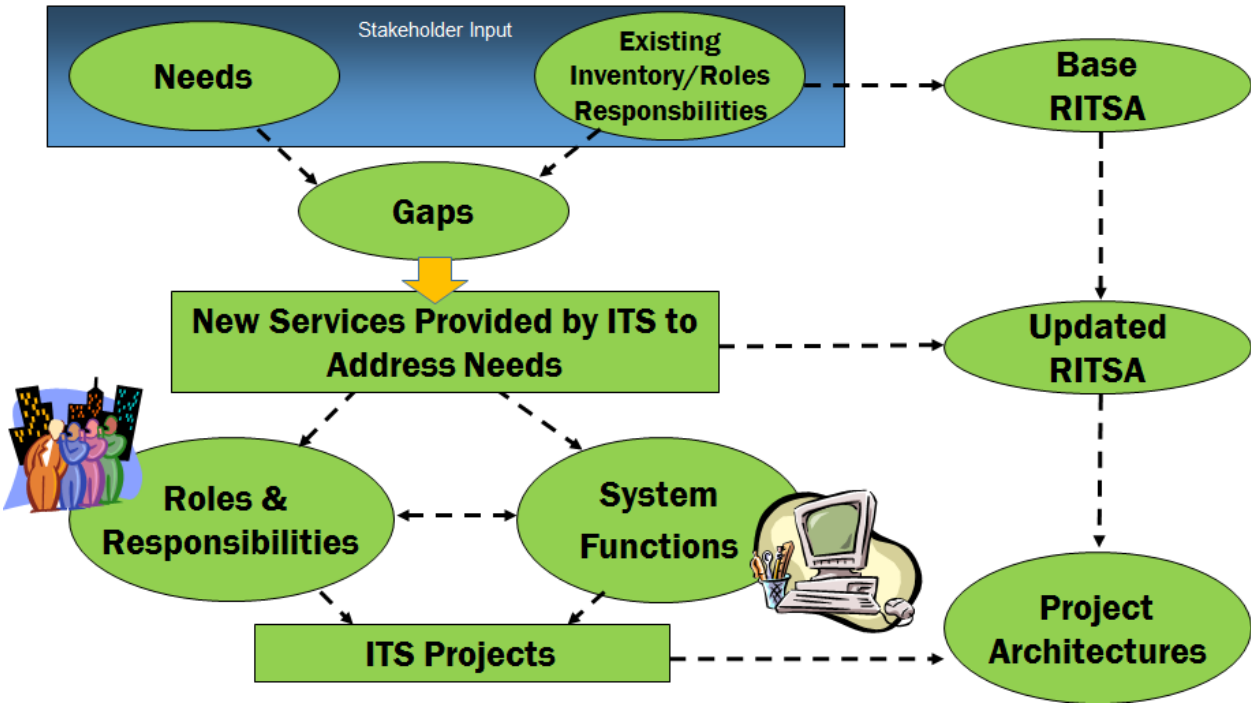

Figure 3: Concurrent RITSA and ITS Planning Activities

Figures 4 and 5 illustrate projects embedded within the St. Louis RITSA, with Figure 4 providing an overview of the projects coded using their ITS Strategic Plan identification numbers (based on priority levels, 1 being the highest). Figure 5 provides an example of how the project is documented in architecture terms, with respect to description, status, timeframe, stakeholders involved, inventory of ITS elements, services provided, and importantly, both existing and planned interfaces to be used. In the example in Figure 5, the "Metrolink AVL Integration with Bus AVL" involves the deployment of an AVL system for the region's light rail system, which would then be integrated with the legacy AVL system already installed on the region's buses, and which would enable other projects identified for

that region such as Transfer Connection Protection (TCP) to be effectively deployed. The project is thus prioritized over TCP activities.

Figure 4: ITS Architecture Output Defining Specific Projects Within the Architecture (St. Louis Example)

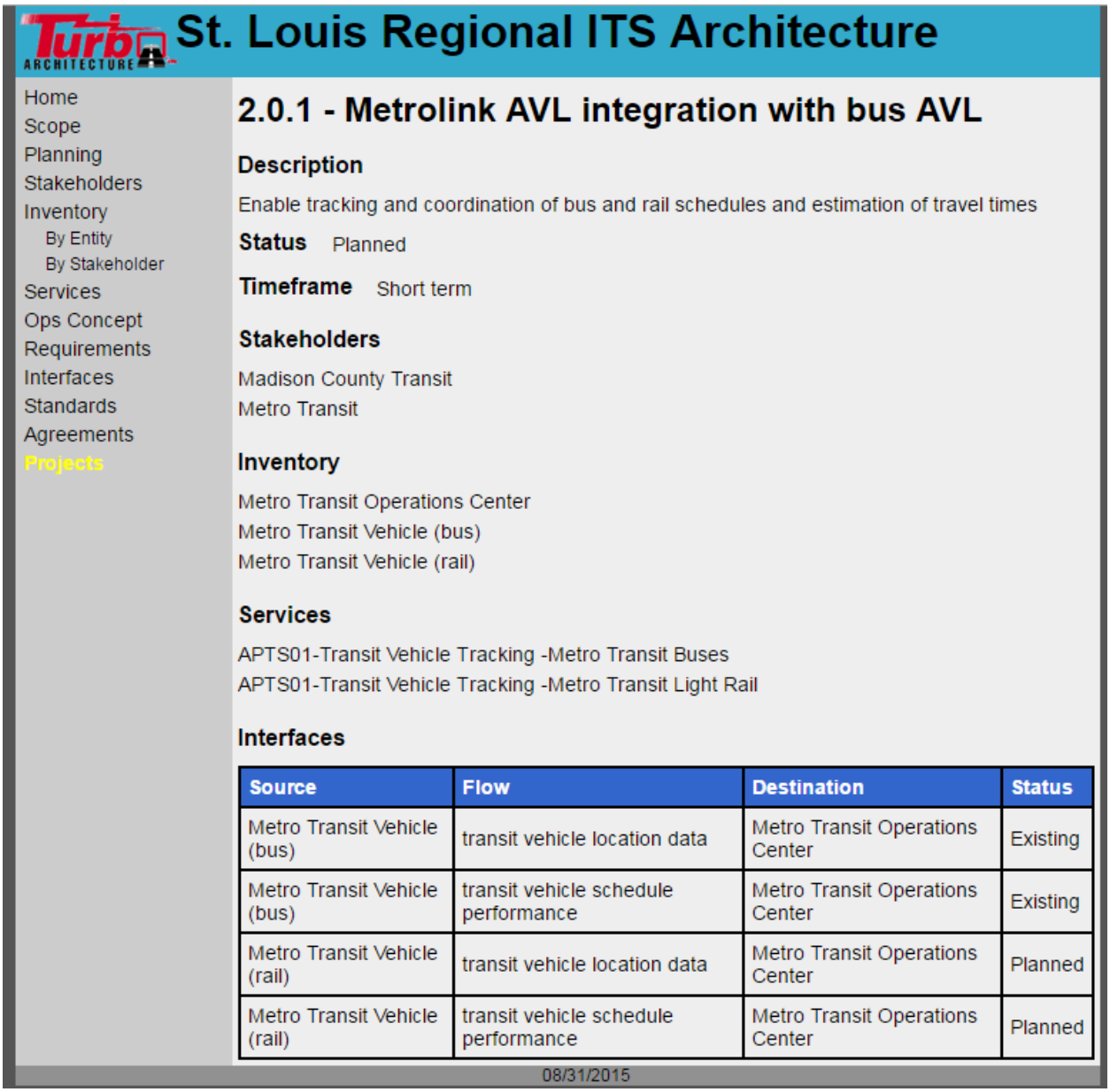

Figure 5: RITSA Components Contained Within a Specific Project (see Project 2.0.1 as referenced in prior figure)

2.1.3 Use of RITSAs as a Tool to Incorporate Connected and Automated Vehicle (CAV) and Connected Corridor Activities into Regional Planning

In general, Federal rules for ITS development (23 CFR 940) emphasize the importance of mapping ITS architectures into planning processes for Metropolitan Planning Areas (MPA's). But there is currently not a companion Federal rule requiring regional transportation plans to incorporate either a RITSA, or

ITS projects developed consistent with the RITSA or the Systems Engineering Analysis process. As a result, observations documented earlier in this document have indicated that ITS definition (e.g., planning, design, implementation) have mainly been considered the province of engineering, operations or Information Technology (IT) professionals within a transportation organization.

With the advent of CAVs and Connected Corridor projects in California, ITS will impact multiple travel modes as well as the transportation infrastructure, as well as introduce requirements including electric charging stations, multimodal facilities such as park-and-ride lots, express bus facilities within managed lanes, and in the future, road-user charging. Much of this will require standardization of functionality, information flows, and communication / interface standards across the State. The implementation of these activities may involve a combination of public sector and private sector investment, and thus requires consideration as part of transportation improvement planning activities. As with any transportation project, ITS projects should fulfill higher-level transportation user needs for a region as well as overall transportation policies.

It will be important to consider the role of a SWITSA in this regard relative to CAVs. Such an architecture could provide the overall framework standardization of statewide activities and components, or that need to be compatible with national requirements (the latter being critical relative to vehicle-focused applications such as electric vehicle charging, V2I and V2V communications, etc.) The Business Case as it relates to using SWITSA and RITSA to support advanced technology projects is that it can reduce redundant activities among multiple regions relative to identifying standards for developing and implementing CAV and other statewide standards, which could be reflected in each RITSA in a standardized fashion, and mapped to the SWITSA.

Likewise, RITSAs should incorporate Connected Corridor activities - not just reflecting individual corridors, but as distinct applications that could be replicated throughout a given region for different groups of stakeholders contained within specific corridors, with standardized roles / responsibilities provided for Caltrans, transit agencies, county and local agencies operating traffic signals and other ITS elements, first responders, etc. For example, while there may be distinct project architectures provided for individual Connected Corridors within a RITSA, standardization of the framework and applications used for each of the Connected Corridors would assure the definition of specific minimum functions and information flows for all Corridors. Then these can be further tailored to each individual corridor project. This activity would result in reduced time and effort needed to develop the individual Connected Corridor projects at a later stage.

Finally, many regions are utilizing the concept of data hubs and standardized data buses to enable private sector and public sector entities alike to access real-time operations data. A consensus felt that such a functionality within a RITSA would assist in helping engage and clarify private sector roles in regional ITS development, particularly as many new applications involving CAVs, transportation services (e.g., Transportation Network Companies or TNCs), and traveler information increasingly engage or involve

the private sector, or are being developed and performed by the private sector with market support, but not necessarily public policy support.

2.1.4 Enhancement of Staffing and Resources to Develop, Use and Maintain RITSAs

In the SAC Workshop discussions, a consensus of stakeholders agreed that the lack of resources and staff continuity over the years for support of RITSA activities has impacted the ability for RITSAs to be effective in supporting transportation planning and ITS project development activities. While there have been training activities at the Federal level for National ITS Architectures and RITSA development, Connected Vehicles, and Planning for Operations, it was felt there needed to be more of a focus on training staff on the use of ITS architectures. Targeting training not just for operations professionals, but also for transportation planners on one hand and IT professionals on the other hand, would be valuable.

In general, the IT professionals and planners' respective understandings of architecture and technology differs to a great extent from the training related to systems engineering and ITS architecture that has been defined to date. There needs to be further understanding on how the National ITS Architecture paradigm relates to actual IT activities as well as how it ties in to transportation planning activities. (The SET-IT tool in support of the new ARC-IT national architecture reference is an important step in developing system engineering documentation where components are directly mapped to a RITSA, yet provides sufficient detail as the basis for a project description and scope.)

Other discussions were related to leveraging responsibilities for regional architecture development, so that an MPO does not always have sole responsibility for architecture development and coordination of stakeholder activities. It was felt that to assure architecture activities carry on beyond initial development, a core group of stakeholders / "champions" involving multiple agencies should jointly support maintenance and updates to the architecture, whether on a rotation or through definition of formal roles. A potential solution may also be the definition of a regional "system architect", in conjunction with others who would support the architecture from the key stakeholder agencies.

The advantage of this approach is that it leverages the cost and commitments to maintaining RITSAs in a manner that enables the other benefits described above.

Finally, Caltrans has recently deployed a tool called ITS System Builder. System Builder provides regional stakeholders with the ability to upload their architectures to a statewide database and also reference what adjoining and other regions are doing with their regional architectures, and in particular with services and functionality that may be of interest to other regions. It also supports Caltrans with documentation of regional architectures and identifying specific gaps for which the SWITSA may provide benefit in connecting with RITSAs or providing coverage in corridors not included within current RITSAs. System Builder can also serve as a clearinghouse for statewide and Federal training materials and guidance for regional stakeholders as well as Caltrans planning and operations staff both in headquarters and in the individual regions. Such a resource can facilitate training and help to some extent to reduce

resource pressures for ITS users at the regional level, although it is not a substitute for providing regional resources and "champions" to develop, support and maintain RITSAs.

Access to System Builder is at: http://149.136.20.175/NetApps/Systembuilder/Default.aspx

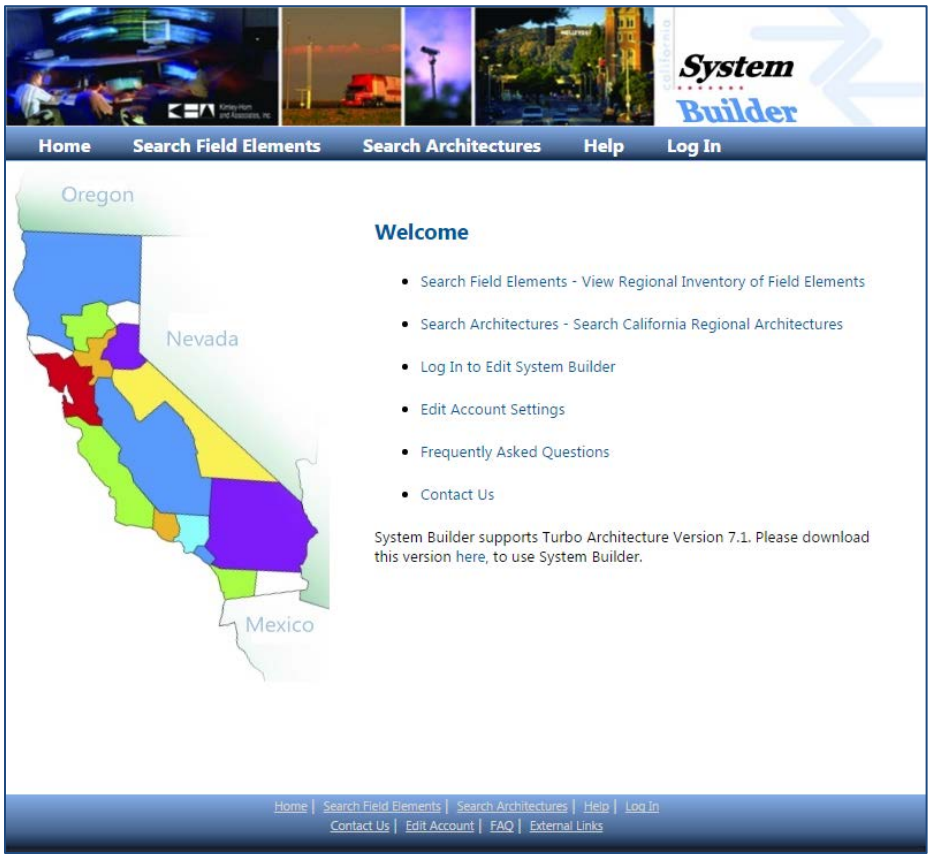

Figure 6: ITS System Builder Home Page (February 2017)

2.2 RITSA/SWITSA Benefits for Project Deployment Activities

This subsection summarizes the benefits to RITSA and SWITSA development, use, maintenance and updating activities, based on the findings presented in Section 2.1 above.

In general, the benefits of developing, maintaining and updating RITSAs include the following:

- Save cost and time in the development of new ITS projects in a given region
- Facilitate applying for and receiving Federal funding for particular ITS project initiatives

- Reduce redundant activities across different regions relative to identifying standards for developing and implementing CAV and other statewide standards

- Identify common interface standards (e.g., data bus) across the region for real-time information exchange, as a basis for incorporating both existing and new public and private sector (e.g., CAV, transportation network/ridesharing services, traveler information) partners

- Standardize the functionality and interfaces for multiple similar activities across a region such as Connected Corridors, thereby reducing time and effort needed to define or add individual projects at a later stage.

2.3 RITSA/SWITSA Benefits for Coordinating Activities Across the State

Managing a SWITSA and providing statewide support functions for RITSA activities enable the following benefits:

- Allows leveraging of cost and training to maintaining RITSAs between public agencies and for different regions, such that benefits can be achieved as indicated above
- Facilitates standardization and interface development for common statewide functions and industry standards, including:
  - Electric vehicle charging stations
  - Statewide tolling
  - Distance-based road pricing
  - Road weather information,
  - Statewide ITS network asset management and monitoring.

Achieving these benefits enables the following:

- Reducing effort needed to obtain an inventory of existing systems and relationships
- Understanding where existing activities could be leveraged so redundant systems and technologies would not be required
- By having a dedicated system architect or architecture group within the owning agency, the region would have the ability to oversee the whole life cycle of the project and how it fits within the RITSA, rather than create a separate architecture that would be incorporated later.
- RITSA development and support would create an inventory of common interfaces and components shared across a region for multiple instantiations of Connected Corridors or similar projects, as well as projects and functions that cross regional boundaries or are maintained on a statewide basis.

2.4 What Efforts are Needed to Achieve Benefits Using SWITSA and RITSA?

Caltrans and the other RITSA stakeholders have generally acknowledged there are potentially significant benefits by developing and maintaining ITS architecture as discussed above. But enabling this to happen requires investments by the stakeholders as well as support from regional agencies and, importantly, Caltrans, who along with California Highway Patrol (CHP), represents a public sector stakeholder that is common to all regional ITS architectures in the state and that acts in a similar role within each of these architectures. The following, as discussed in the SAC Workshop in Los Angeles in February, represent recurring themes relative to the benefits described in the above sections, and are integral to making the Business Case for SWITSA and RITSA activities:

- Need to demonstrate benefits and cost savings using RITSA to support ITS project development
- Document best practices and guidance on how to utilize RITSA to support ITS planning and implementation
- Provide guidance for organization and staffing for ITS activities along with coordination between regional agencies to support architecture development, use and maintenance (this would relieve pressure on MPOs or other single agencies who have handled architecture development in the past)
- Need a centralized resource as repository of RITSAs across the state as well as guidance and training (Use of ITS System Builder and creation of RITSA user groups throughout the State are potential options)
- Training for various levels of technical expertise (including IT people) is needed, as well as refinement / standardization of terminology (e.g., many public sector officials as well as the general public still don't understand what "ITS" is)
- Architectures should identify future project activities or be updated (between cycles if needed) to reflect new projects.

2.5 Preparing for the Future – CAV

Perhaps the most compelling arguments in the Business Case for statewide and regional ITS architecture development are related to emerging technologies, notably Connected and Automated Vehicles (CAVs). The introduction of CAV technologies has opened up a new world of opportunities for ensuring the efficient movement of people and goods safely and economically, while protecting the environment. Indeed, the estimate by NHTSA that, connected vehicle technology could potentially address 80% of all

unimpaired crash scenarios is, in itself justification to support the adoption of these technologies for safety reasons alone.

The "Connected Vehicle Environment" (Figure 7) more explicitly goes beyond ITS infrastructure (and current RITSAs) to address communications to and from, and between, vehicles. The standardization of these communications as well as their utilization on a national and statewide basis must be addressed as part of all statewide and regional ITS architecture activities. In particular, this environment will require the increased engagement of the private sector as well as further standardization of data sharing capabilities, leveraging from efforts already underway as part of ICM and Connected Corridor activities.

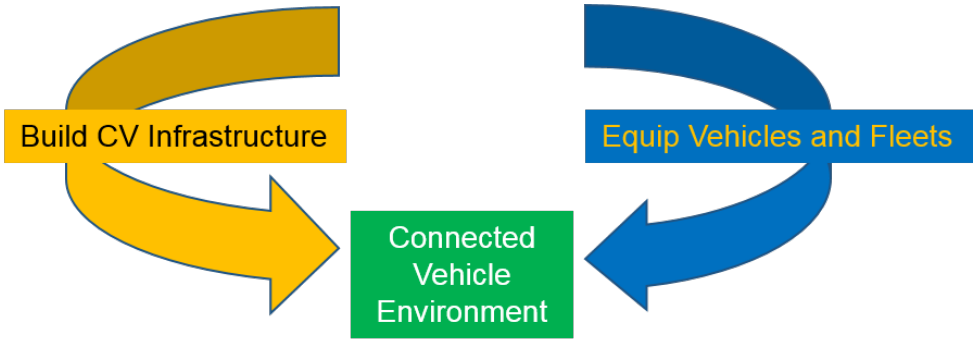

Figure 7: Connected Vehicle Environment

It is generally accepted that the immediate main barrier to comprehensive CV deployment and equipping of the vehicle fleet - that of allocation of universal, standard communication bandwidths - will be resolved by National Highway Transportation Safety Administration (NHTSA) in the short term through its mandate for the Basic Safety Message (BSM). However, it is also clear that Caltrans and other transportation agencies will play a very important role in ensuring the benefits associated with CAV are achieved by incorporating emerging technology applications that are relevant to the transportation policies, goals and objectives throughout the state and in each of the regions.

2.5.1 How Will ITS Architecture Change?

Over the past decade, there has been substantial investment in the US and abroad, both in the public and private sector, in first demonstrating and then introducing both connected and Automated mobility technologies. In 2012, a Connected Vehicle Core System concept was developed by the U.S. Department of Transportation (USDOT), leading to the development of the Connected Vehicle Reference Implementation Architecture (CVRIA), providing a framework for current pilot projects and future ITS applications that utilize vehicle data and provide functionality for the traveler, the vehicle, third-party product and service providers, and the transportation operator, e.g., Caltrans, MPOs, regional transit providers, counties and local agencies. The CVRIA framework encompasses vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V), and center-to-infrastructure (C2I) standards.

The CVRIA has recently been "mainstreamed" into the National ITS Architecture (the basis for current SWITSA and RITSA activities) through ARC-IT. ARC-IT has focused on the integration of the physical and communications architecture layers, with functional and institutional layers added in subsequent updates, along with modules to support planning for operations and benefits assessment. The newly-updated architecture will further integrate the vehicle as a key component in transportation operations, both as a data source and conveyance of real-time information, whether providing route guidance and advisories to the driver or enabling full and safe vehicle operations on specific routes, including emergency responses to avoid collisions.

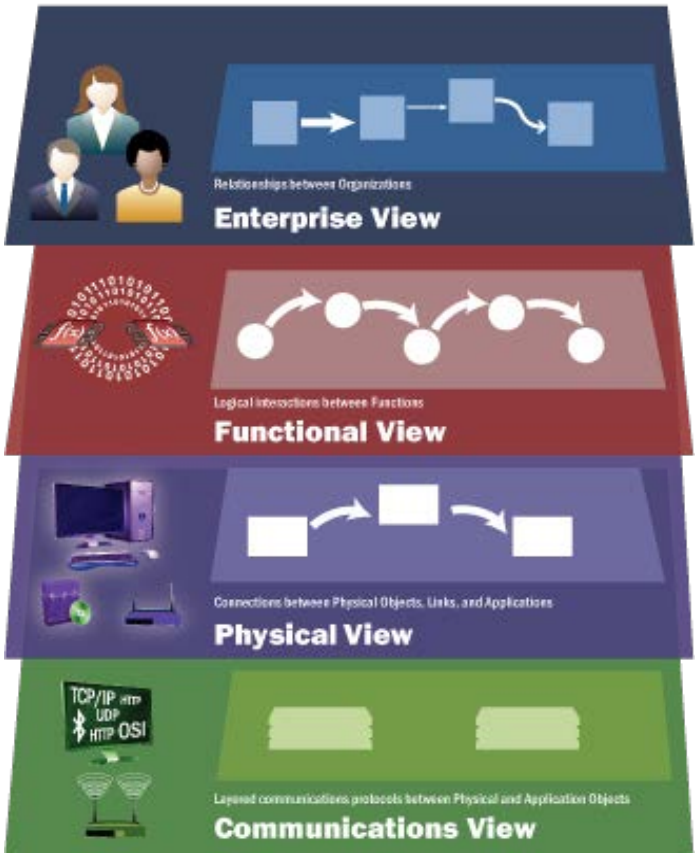

Figure 8: The Future Views of RITSAs

A Regional Architecture Development for ITS (RAD-IT) tool evolved from the existing Turbo Architecture tool has been introduced alongside ARC-IT. The System Engineering Tool for ITS (SET-IT) developed for CVRIA and utilizing Visio as its graphical base has continued as a next-level-of-detail tool for implementing ITS/CAV applications. Both RAD-IT and SET-IT will be able to reference the same architecture build, which in turn will be able to leverage directly from legacy Turbo Architecture (Version 7 and earlier) files.

Undoubtedly, revisions to Caltrans' ITS System Builder tool will be required over time as Architectures are updated to incorporate additional views (layers) of detail as per the above.

2.5.2 How Will Today's ITS Environment be Impacted by CAV?

From the perspective of SWITSA and RITSA development activities, the new architecture framework makes investment in CAV activities even more imperative. There will need to be training activities, as well as incorporation of industry standards, private sector partnerships, and further connectivity to planning-for-operations initiatives. In general, CAV will impact ITS developments as follows:

- ITS and traffic control Infrastructure will continue to play an important role in traffic operations and management for the foreseeable future. For example, Closed-circuit television (CCTV) continues to be of significant importance in confirming incidents and congestion, and is an important information source to the public. Traffic signal control will continue to be a primary element of arterial traffic operations, enhanced by technologies sharing signal data (i.e., Signal Phase and Timing, or SPaT) and displays inside vehicles, and likely improving operational efficiency and safety. Dynamic message signs (DMS) provide useful advisory and congestion information, although the increased availability of such information on mobile and in-vehicle applications in the future may reduce their necessity over time.

- Standards for V2V, V2I and in-vehicle applications are still maturing. Although certain standards such as SAE J2735 and IEEE 1609 which guide DSRC have been under development for a decade and will be the base standard for V2V safety-related messages and immediate traffic control messages through V2I, other wireless technologies may be used for less time-/location-critical messaging.

- Control and information functions will require two different levels of communications to be developed in the short term with public agency resources (utilizing applicable national, international, and auto industry standards). These are summarized below:

    - The capability to communicate traffic control functions and displays to the vehicle (e.g., SPaT for signals and ramp meters), and conversely capture vehicle data will require immediate, location-sensitive, and two-way V2I capabilities.

    - Real-time information will include a richer, more location-specific array of advisory information (e.g., speed limits, queue warnings, lane closures, alternate routes) through a variety of portable applications for mobile phone and in-vehicle systems. It will require more location sensitivity and timeliness, but not immediate communication capabilities.

In-vehicle technologies primarily are 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 Automated operation, as well as provide control and information functions that to 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.

2.5.3 When Will All This Happen?

Although CAV technologies collectively have the elimination of fatalities and crashes as an ultimate goal, it will take time before current agency functions associated with incident management and first responders change drastically, and thus, those applications would need to be reflected in RITSAs.

Over the next 20 to 30 years, the vehicle fleet will include a gradually increasing mix of both connected and Automated technologies. This interim period mixing different vehicle types and functions (e.g., smart shuttles, Automated delivery vehicles, commercial vehicles, as well as driver-operated vehicles with varying levels of connectivity and automated features), will require preparedness for different types of incidents that could occur.

While ITS and CAV standards for information flows and security are still maturing, it will be important for SWITSA and RITSA activities to leverage from the current advances in these technologies and leverage techniques for public-private partnerships so that all regions have the ability to develop and implement projects that enable partnerships with the private sector and that utilize industry standards even as they evolve.

However, until 100% of vehicles are equipped, not just with transmitters for basic safety messages over V2V, but with in-vehicle signage, information warning capabilities and the associated control systems to assist or take over for the driver, the public agencies will need to provide infrastructure for traffic control and flow management, in parallel with wireless networks and in-vehicle capabilities.

The public sector stands to gain greatly from the deployment of applications that collect data from On-Board Equipment (OBE)--equipped vehicles to enhance their picture of the road conditions. Assuming that an average of 7 million cars are sold each year in a market with 253 million vehicles, 3% of the vehicle fleet each year would be added as accurate data sources for location, speed, and conditions. Public agencies could deploy RSEs to collect significant data about the roadway, and over a three- to four-year period (depending on uptake of new vehicles with OBE), 10% or more of the fleet could provide useful operational information. Expected market penetration over a decade or longer would lead to a sizable majority of the vehicle fleet being equipped (acknowledging there will always continue to be classic or historic vehicles in the fleet that pre-date OBE installations). In general, public transit agencies, freight

industry, and auto manufacturers are in the process of implementing new regulations to equip more modes in the near future.

In the end, updates to both RITSAs and the SWITSA (along with ITS System Builder) would be needed on a regular basis as new applications and standards evolve in the coming decades. Whole many pilot activities may be focused on larger regions, the ultimate deployment of these technologies will impact all regions over time.

3. Potential Caltrans Initiatives

Ideally, this project can promote the ITS Architecture Business Case presented above by helping encourage regions to further enhance their RITSA activities in support of their transportation systems management and operations programs. However, the direct products of this project are specifically directed to Caltrans. As such, the focus of this project becomes, "How can Caltrans promote statewide and regional ITS architecture activities?"

As the one transportation agency in the state that serves as a stakeholder in every region's transportation activities, Caltrans stands to gain significantly working with regional architectures and a SWITSA that represent the latest activities and applications and are updated on a regular basis, and that also address current initiatives across the state such as Connected Corridors and the emergence of CAVs.

As such, Caltrans is in an optimal position to advocate for RITSA development, use and maintenance. To do this requires that Caltrans support for RITSA activities, along with outreach and coordination, be done not only at the statewide level (through Headquarters), but in particular at the District level. Furthermore, this support must include not only operations and technology staff, but statewide and district planning staff. RITSAs should reflect activities that Caltrans is undertaking, relationships with other agencies that Caltrans needs to support its mission, and should document activities and projects that Caltrans needs to implement in the Districts as well as on a statewide basis.

3.1 Headquarters Initiatives

Within Caltrans Headquarters, there are five particular areas of focus either underway or that should be built upon to further Regional ITS Architecture activities.

3.1.1 Education and Support of Caltrans Management on the Value of RITSAs

There have often been misperceptions on what an ITS architecture is and its purpose. Meetings with Caltrans management staff at the earlier stages of this study indicated that there could be important synergies between ITS architectures and TSMO activities, particularly in the connection between Regional Concepts of Transportation Operations (RCTO) and the framework for regional coordination

which is enabled through development of a RITSA. The definition of projects based on RCTO-defined needs, goals and objectives can be readily incorporated into a RITSA along with prioritization activities, so that projects can effectively form building blocks for implementation of the RITSA as a "living, breathing system".

It is recommended that RITSA education and support activities for Caltrans planning and operations managers be closely tied with TSMO and RCTO activities, with a focus on how coordination of these activities can facilitate deployment of ITS projects and reduce the cost of developing and implementing the projects.

3.1.2 Changes to ITS Planning Procedures that Map RITSAs to Transportation Goals and Objectives, Including Operations-Oriented Activities

Although MPOs retain the lead responsibility for regional transportation planning, the planning functions in each of Caltrans Districts and Statewide is critical to defining programs and projects that are of the highest priority to the Department. Caltrans has embarked on a high-level focus toward TSMO activities. While a RITSA by definition maps to regional planning goals and objectives as stipulated in 23 CFR 940, the architecture components that involve Caltrans should also be mapped to Statewide and District operational goals and objectives. Likewise, the SWITSA should focus on Statewide Goals and Objectives relative to intercity and cross-cutting ITS activities that are of statewide relevance. The Planning for ITS Guidance developed a decade ago by Caltrans should be updated to reflect this closer connectivity with planning goals and objectives and should detail how those goals and objectives, where prioritized, could also impact prioritization of ITS projects.

To accomplish this, it is recommended that Caltrans headquarters lead an initiative to provide training of non-ITS operations staff at both Statewide and at the District level on the role of ITS in transportation operations. This woul address the relationships of planning and RITSA activities such that even professionals without an ITS or traffic management background can successfully and knowledgably consider the role of technology in improving transportation systems activities.

Likewise, the statewide SHOPP projects should be incorporated into SWITSA and RITSA activities, and conversely, other SHOPP projects may be defined and developed as a result of architecture development activities, driven in part by standards and coordination activities that may be needed to further Caltrans' mission.

3.1.3 Path for Migration of RITSAs to Expanded National ITS Architectures Involving Connected Vehicle Implementation Elements

As discussed in Section 2.5 above, the new national architecture reference, ARC-IT, includes additional or revised layers (physical, communications, functional and institutional) reflecting the increased complexity of incorporating connected vehicle communications (V2I and V2V) into ITS applications. The

revised RAD-IT tool is compatible with older Turbo Architecture files but enables the addition of new layers to the older architecture as well as the addition of new ITS and CAV service packages. The planning guidance provided by Caltrans will need to be flexible in incorporating the new elements while assuring that recently-updated architectures are not suddenly obsolete. Distinct processes may address the following:

- RITSAs that have not been updated since 2010 (may require development of a new architecture using ARC-IT and the RAD-IT tool as the basis)
- RITSAs that have not been previously mapped with regional transportation planning activities (may require updates, mapping of current programs to plans, and updates to applications to reflect both ITS and CAV activities, including importing the existing architecture into the new RAD-IT tool)
- RITSAs currently being updated or recently updated (import architecture into RAD-IT tool and incorporated CAV-related applications)

In addition, a path for update of the Caltrans ITS System Builder may be required to incorporate the additional architecture layers introduced with ARC-IT.

3.1.4 Internal and External Outreach on the Use and Enhancement of ITS System Builder

The ITS System Builder tool provides a useful platform for the sharing of RITSA information between stakeholders across the state as well as a useful tool for documentation of statewide ITS activities. However, it is of the greatest use if both the SWITSA and the most current RITSAs are uploaded and outdated architectures are superseded in a timely fashion. The revised ITS Planning Guidance as well as various Caltrans outreach activities should address how to make the most effective use of ITS System Builder and its training / data resources. Including examples of specific services and applications that may be already in place in specific regions but are of interest in other regions.

As discussed above, updating of System Builder to incorporate key elements of ARC-IT (including connected vehicle-related activities) will be highly beneficial as the architecture activities evolve into the CAV era.

3.2 At District Level

3.2.1 Education and Support of Caltrans District Directors and Division Chiefs on the Value of RITSAs

The closer that RITSAs are tied to the overall mission, goals and objectives of the Caltrans District(s) within the region, the more relevant that RITSA will be to Caltrans operational activities as well as programs and projects that include Caltrans as a key stakeholder. As such, development, update and

outreach efforts for RITSAs should include presentations and outreach activities targeted for managerial-level staff and decision-makers, whether from the Caltrans Districts (including the chiefs for planning and operations as well as the District Director) or from other primary agencies (e.g., city, county, transit) within the region. Executive-level talking points are very important in this regard.

It is not expected that full training on the construct of a RITSA would be necessarily appropriate. But it is important for decision-makers to see the usefulness of RITSAs in helping to scope ITS and operations projects, identify specific relationships and interfaces that are needed to enable regionally relevant projects to be deployed successfully, and reduce the efforts needed to develop project concepts.

Both Caltrans headquarters (through statewide ITS training activities) and MPOs or other agencies leading RITSA activities should participate in this effort to assure that District ITS operations and planning initiatives follow a regional framework, and enable good working relationships between Caltrans and other agencies. This is of crucial importance for Connected Corridors projects, and is also essential with the implementation of CAV projects that require standardized V2I communications with roadside equipment independent of jurisdictions.

3.2.2 Caltrans District Planning Coordination with MPOs and Other Agencies on RITSA Development

The MPO is typically in the lead role for development of RITSAs. However, depending on the size and complexity of the region, there may be a number of regional subarchitectures (e.g., County ITS Architectures). This introduces a degree of complexity for Caltrans Districts in terms of coordination with various agencies on their ITS architectures and project initiatives.

While it is incumbent upon the architecture developers to outreach to and include Caltrans Districts as integral members of the architecture development team and as stakeholders, it is also important for both Caltrans District planning and operations divisions to provide consistent input to the MPO's and other entities developing architecture projects. The development and implementation of Connected Corridors provides an excellent opportunity for Caltrans to leverage the outreach needed for architecture development activities toward incorporated the essential functions and relationships required for Connected Corridors into the regional architectures.

Likewise, implementation of standards and guidance for CAVs (including V2I communications, charging stations, preferential operational strategies for Automated urban and freight vehicles) requires close coordination and working relationships to assure consistency between Caltrans and other agencies, as well between Caltrans Districts and SWITSA activities being handled at the Headquarters level.

3.2.3 Developing or Participating in a RITSA Partnership for the Region

Development of RITSAs has generally been a task of MPOs as per the language in 23 CFR 940, which identified regional architectures as multi-modal in nature and focused on metropolitan planning areas. However, the deployment of ITS activities has traditionally involved staff with expertise in traffic engineering and operations (including electrical engineering and communications expertise where needed for field equipment and networks) along with information technology experts.

The development of architectures has often focused on the planning agencies, but maintenance, use and updating of architectures so that they serve as a useful documentation of regional ITS activities and an integral part of the deployment road map means that experts from the multiple specialty areas and agencies need to be engaged on a continuous basis. Often, MPOs do not have such resources or expertise to do this alone. Caltrans, as the one agency across the State that serves as a stakeholder in every region and provides planning, operations and IT capabilities in all Districts, could be an important entity in helping the MPO form a regional partnership where various entities can work together (rather than just one agency) in developing, using, maintaining and updating the RITSA. Doing this requires several commitments at the Caltrans District level:

- Identify the "point person" or "Champion" for supporting RITSA activities at the District level, who could be either senior-level Planning staff or senior-level Operations staff, and would have this role as one of his/her major responsibilities

- Assure that there are representatives from District Planning and Operations staffs who are trained on RITSAs, familiar with regional ITS program plans, the SHOPP, and District program activities such as Connected Corridors, and who are willing to both work together as well as engage with external agencies such as MPOs, cities, counties, transit providers, and other stakeholders who would jointly work together on a continuous basis (e.g., quarterly or more often) to review and manage the architectures so they reflect both current activities as well as programmed and future projects

4. Summary and Next Steps

4.1 Updates to National ITS Architecture

The newly-updated national architecture reference (ARC-IT) integrates the vehicle as a key component in transportation operations, both as a data source and conveyance of real-time information, whether providing route guidance and advisories to the driver or enabling full and safe vehicle operations on specific routes, including emergency responses to avoid collisions. As part of the new architecture update, there have been commensurate updates to the architecture development tools, which will in turn require updates to the Caltrans ITS System Builder Tool, along with updated to Caltrans ITS Planning Guidance, due to the richer nature of data that is both required and provided through the tool.

4.2 Updated Caltrans ITS Planning Guidance

The above recommendations and Business Case considerations, along with the updated ARC-IT inputs, will result in changes to the approach of developing RITSAs in California, as well as creating an impetus for updating and better defining the SWITSA. These changes will all be key components to changes in the Caltrans ITS Planning Guidance, with the important output being a much tighter relationship between SWITSA and statewide transportation planning and operational project planning investments, as well as between RITSAs and regional transportation planning and TSMO activities.

Caltrans Headquarters and the Districts will each have key roles to play in providing not only support to MPOs and other entities who are leading architecture development activities, but themselves providing leadership in promoting and supporting architecture development. This may include providing resources to support MPOs in assuring the architectures are reflecting current and program activities, or in helping Caltrans improve its outreach and relationships with other agencies, which in turn will further initiatives such as Connected Corridors and CAV activities.