Part I – Technical/Management Approach

I.1 Introduction

The Gold Rush started the mass migration of pioneers to California, and that pioneering spirit continues today in terms of the State’s entrepreneurial attitude and willingness to try innovative new ideas. Apple, Google, Tesla, Qualcomm, and SpaceX are excellent examples of businesses that thrive in this environment, and help stimulate a highly productive economy that is built on bold concepts. Moreover, if the State of California were a separate nation, its economy would rank seventh in the world. The California multimodal surface transportation system is the fuel that powers this great economic engine, carrying workers to their jobs and moving goods to markets.

While the transportation system that propels this economic juggernaut is effective, one can hardly argue that it is efficient. In terms of mobility, California travelers suffer 535,000 vehicle-hours-of-delay every day, the highest in the nation, with the associated loss of productivity, wasted fuel consumption, and adverse impacts on air quality. Incidents on the roadway – typically automobile collisions – cause about one-third of this delay. Consequently, any reduction in the number of collisions also would significantly reduce delay, improve mobility, and continue California’s aggressive pursuit of attaining air quality levels that are healthy for all of its citizens. California is home to 11 major ports, spanning 1,000 miles of coast from the Oregon border to San Diego County. Of these ports, the Ports of Los Angeles (POLA) and Long Beach (POLB) make up the busiest port complex in the nation, creating substantial mobility and air quality challenges into the foreseeable future. Clearly, there is plenty of room for improvement.

With these challenges in mind, an unprecedented partnership of public sector, private sector, and academic entities are proud to present this proposal as the next step on the path to broad deployment of Connected Vehicle (CV) technologies across the most populous state in the nation. The proposal, called “One California,” embodies the principles identified in the California Transportation Plan 2040: creating a sustainable and interconnected transportation system that encourages economic vitality, protects precious natural resources, promotes the health and well-being of all Californians, and meets people’s needs equitably.

One California’s scientific and technical approach to this proposal is CV application-centric. As detailed in Volume I, Part III, this approach focuses on the shared transportation challenges and needs affecting California’s urban regions with growing populations. These challenges and needs

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MTC
Successfully deployed four Urban Partnership Program projects that remain in operation: 511 Parking Info, 511 Real-Time Transit Departure Info, 511 Enhanced Multimodal Trip Planner, and use of Clipper® Transit Fare Card for parking payment.

METRO
Successfully partnered with USDOT to deploy FRATIS CV applications; deployed one of the largest wireless signal systems in the nation, and invested over $1B on signal synchronization and bus speed improvements.

SANDAG
One of the first MPOs in the U.S. to include Connected Vehicles in its RTP; successfully deployed Integrated Corridor Mgmt. System on I-15 (Best of ITS 2013 Award; CTF Operational Efficiency Award 2014).
were identified in recently held stakeholder workshops that occurred within each region. The approach then examined which set of USDOT-defined and new custom CV applications should be applied to address these challenges and needs across four key user-needs categories: mobility, environment, safety, and agency efficiency.

One California has implemented an approach of using CV applications and suites, such as Multi-Modal Intelligent Traffic Signal Systems (MMITSS), Applications for the Environment: Real-Time Information Synthesis (AERIS), and Freight Advanced Traveler Information Systems (FRATIS), with which it has direct involvement and knowledge, primarily through development of the prototype versions in prior projects. This approach will enhance the opportunity for successful deployment, while minimizing the risks. The chosen applications, as highlighted in Figure I.1, will be deployed, integrated, and operated across three regions (San Francisco, Los Angeles (LA), and San Diego) in a manner that promotes the “develop once, deploy many times” philosophy. This integrated project represents a single statewide Pilot Deployment site, and includes the operation of 16 CV applications – 13 USDOT-defined applications and three One California custom applications – encompassing 70 miles of Dedicated Short-Range Communications (DSRC)-enhanced corridors.

The One California proposal represents a bold and innovative approach to CV deployment, submitted by the California Department of Transportation (Caltrans) and combining the skills and expertise of transportation agencies from three of the most progressive regions in the United States – LA, the San Francisco Bay Area, and San Diego – ranked number 2, 5, and 9 respectively, among the top 10 most populous U.S. cities, and whose regions account for nearly six percent of the U.S. population. The most critical members of the One California team (hereafter called “Team”) are the transportation agencies representing the three regions: the Metropolitan Transportation Commission of the San Francisco Bay Area (MTC), the Los Angeles County Metropolitan Transportation Authority (METRO), and the San Diego Association of Governments (SANDAG). In partnership with Caltrans, MTC and SANDAG are responsible for planning transportation improvements for all roads and all modes of travel in their regions; METRO is the leading transportation funding agency in LA, and is supported on the Team by the County of Los Angeles Department of Public Works (LADPW), which maintains 1,800 traffic signals Countywide. Collectively, these agencies have all demonstrated the necessary planning processes and funding capacity to deploy
CV technologies far beyond this Pilot effort. In this case, the value of the whole Team is definitely greater than the sum of its parts.

Figure I.2 presents a timeline of the seminal activities in the One California CV program to date. The activities outlined here, which also encompass weekly conference calls and multiple in-person workshops, consist of over a year of intense public and private sector activities in preparing for this proposal submission to the Federal Highway Administration (FHWA). This extra effort highlights the level of commitment, as well as the maturity level, of the bid to conduct the One California CV Pilot Deployment (CVPD) Project.

![Figure I.2 One California CV Pilot Deployment Project Timeline to Date](image)

In addition to the three regional transportation partners, numerous local cities, transit agencies, port authorities, and industry associations are supporting the Team, and Letters of Support from these stakeholders are outlined in Volume I, Part II.

The Team will also receive support from both academic institutions and private sector companies. Caltrans’ academic partners at the University of California (UC), Berkeley’s Partners for Advanced Transportation Technology (CA PATH) and UC Riverside’s Bourns College of Engineering-Center for Environmental Research and Technology (CE-CERT) have worked with Caltrans for more than 25 years, performing technical research in CV-related areas, including the implementation and operation of the California CV Test Bed, development and testing of the MMITSS and AERIS applications, and the development and testing of smartphone-based CV applications under the Connected Traveler Project as part of the USDOT’s SafeTrip-21 Initiative.

The Team has also selected private consultants to support and deliver the 13 Phase 1 tasks. This Phase 1 consultant group, led by Iteris, Inc. and including Leidos, Parsons Brinckerhoff (PB), and System Metrics Group (SMG), has significant experience across...
all aspects of the Phase 1 Concept Development technical areas, and has been involved in the systems engineering, development, and testing of CV projects, including the Connected Vehicle Reference Implementation Architecture (CVRIA), the SET-IT Tool for Concept of Operations (ConOps) Development, the Security Credential Management System (SCMS), and the Michigan Safety Pilot.

Investing in the One California proposal will lead to a big payoff. The seeds for CV deployment that the Team’s regional agencies will plant will result in growth out to their entire metropolitan areas. Eventually, this seed will grow to encompass other California metropolitan areas, including Sacramento, the Inland Empire, and the rapidly growing cities in the Central Valley – leading to ubiquitous coverage of CV applications across California. Moreover, enhanced by this partnership with FHWA, and through proposed plans for continuous national-level outreach, the One California CVPD Proposal represents an unparalleled opportunity to establish the CV deployment baseline that will lead to nationwide deployment of CV applications.

The contents of this proposal demonstrate the scientific and technical merit of the One California approach, and are the culmination of unprecedented planning and preparation efforts. It demonstrates the Team’s strength and commitment, and the depth of its vision. It highlights the significant funding match commitments that Caltrans and its partners are applying to this partnership with FHWA, and is the basis on which One California proposes to work hand-in-hand with FHWA to usher in an historic new era by taking the next step on the path to a connected future for the nation’s transportation system.

I.2 Technical Approach

Task 1 – Program Management

One California’s Program Management approach draws on the application of the Project Management Institute’s (PMI) Project Management Body of Knowledge (PMBOK) best practices to meet FHWA-specified project management requirements for this program. Figure I.3 provides an overview of this approach.

The Team’s Program Management approach involves drawing the best management talent from across member agencies. Overall management of the project will be under Greg Larson of Caltrans. Janet Banner of MTC (Concept Development Lead (CDL)), Steven Gota of METRO (System Development Lead (SDL)), and James Dreisbach-Towle, PMP, of SANDAG (Project Management Lead (PML)) will assist Mr. Larson in management of consultant activities and Team coordination, and the Phase 1 Consultant Iteris, Inc. will also provide its Senior Vice President Alan Clelland, as the Project Manager for concept development. A Project Management Council, consisting of agency executive management, will provide policy guidance while an Advisory Committee consisting of agency technical personnel and University research personnel will provide technical input.
and feedback. Additional details of the Team’s management approach can be found in Volume I, Part II of this proposal.

**Figure I.3 Program Management Plan (PMP) Work Steps and Unique Features**

- **Hold Kickoff Meeting**
  - In Washington, D.C. within 15 days of award.
  - Review scope with USDOT and identify key work steps to bring project on-line.
  - Present Stakeholder Registry (supports Communications Plan).
  - Review PMP (see below).

- **Develop Project Management Plan**
  - Prepare and deliver PMP following PMBOK Standard (ANSI FS-PMBOK 2013) – including Scope Mgmt, Project Schedule with Critical Path, Schedule Mgmt, WBS, Communications Plan, Cost Mgmt, Quality/Configuration Mgmt and Risk Mgmt.
  - Respond to changing project needs/updates as needed.

- **Proactively Manage Risk**
  - Follow a Risk Mgmt approach based on the successful application of the USDOT Risk Register used on LA-FRATIS.
  - Reassess risks monthly (documented in Monthly Report).

- **Work Breakdown Structure, Schedule, and Budget Tracking**
  - Decompose tasks to three-level WBS.
  - Develop draft/final project schedule in MS Project/Gantt chart format; assess and label critical path.

- **Monthly Progress Reporting**
  - Report on deliverables status (actual deliverables submitted to date, progress versus plan).
  - Report on past month’s accomplishments; plan for next month.
  - Continuously report project costs (including Estimate to Complete), project risk mgmt status and detailed schedule.

**Task 2 – Pilot Deployment Concept of Operations (ConOps)**

It is not an understatement to suggest that this ConOps task will be the single most important activity in Phase 1. The ConOps cements the marriage between the user and the systems engineer – and if done right, results in applications that are accepted and utilized by the users, which then can translate into changes in operations that provide the real-world performance benefits that were intended from the beginning of the process. The Team brings recently proven ConOps development experience on U.S. Department of Transportation (USDOT) CV and advanced intelligent transportation systems (ITS) programs to the table, having been involved in the development of the USDOT-sponsored FRATIS ConOps, both the I-15 (San Diego) and the I-880 (San Francisco Bay Area) Integrated Corridor Management (ICM) ConOps, and various Advanced Traffic Management System (ATMS) Corridor-based ConOps in the LA region. These ConOps led to successful major prototype application development and testing programs for USDOT and local agencies. Based on these experiences, the Team has developed a best
practices process of conducting a ConOps – fully consistent with IEEE Std. 1362-1998. Figure I.4 illustrates how the Team has tailored this process to develop the ConOps for the One California CVPD.

**Figure I.4 One California ConOps Technical Approach Overview**

The One California CVPD ConOps will include language and graphics that regional transportation stakeholders can understand, and will present a plan for day-to-day operations of the CV applications across the regions, based on what the users want from the system or expect the system to do for them. Moreover, it will include a strong set of **CV Operational Enhancement Scenarios**, shown as one of the outputs in Figure I.4, that will be fully based on user input; the operational scenarios will include “day-in-the-life” descriptions of how actual CV users will utilize the system and how they will benefit from system use.

The ConOps will document how the application bundles address the safety, mobility, and environmental goals of the CVPD. The ConOps process will include stakeholder input on the desired characteristics of the applications. This input will be used to confirm that the applications are addressing needs, have measurable objectives, and produce the data required for evaluation in a cost-effective manner. The initial concept for each application will be refined and improved as it is vetted through the operational enhancement scenarios. Users/stakeholders across the applications will include, but not be limited to: agency operations staff, agency vehicle fleet drivers, transit fleet drivers, transit passengers, trucking dispatchers and drivers, work zone operations staff, transportation advocacy groups, motorists, and pedestrians.
A unique feature of the One California approach will be to conduct a multilayered stakeholder engagement and user recruitment effort across the regions. Depending on the user groups, the stakeholder engagement and user recruitment will include both structured half-day workshops and in-person outreach interviews. The starting point for this effort will be the Stakeholder Registry in Task 1. This user/stakeholder engagement approach will continue through the System Requirements task, and in fact, will continue through all three phases of this project. Moreover, to further enhance traceability between the eventual deployment in Phase 3 and the initial user needs for the applications, the Team will establish a broad set of user groups that One California can continually revisit as the Team plans, develops, and deploys the applications.

Finally, a very important and unique feature of the One California ConOps approach is that a significant portion of the user needs and conceptual development work – stakeholder needs outreach/workshops, establishments of partner relationships, and the conceptual framework for the employment of specific CV applications – has already been completed in the past year while the Team has been developing the One California CVPD.

**Task 3 – Security Management Operating Concept (SMOC)**

The Team is acutely aware of the importance of security for CV applications. Recent publicity about hackers attacking automotive systems and infrastructure systems has raised public awareness of the threats, and serious damage could be done to the reputation of CV systems if any CVPD project were to be successfully breached by hackers. The Team will rely heavily on the security infrastructure that USDOT has developed for CV systems, especially for the safety-critical DSRC communication links. Each of the public infrastructure systems that will be integrated with the CVPD applications will be reviewed carefully for its security protection to minimize the likelihood of a successful attack through an unprotected component or subsystem (such as a traffic management or signal control system).

The SMOC will address three related, but distinct challenges:

1. Protection of the privacy of data collected from participants in the CVPD requires careful coordination with the ConOps development in Task 2, the Performance Measurement and Evaluation work in Task 5, and the Human Use Approval work in Task 8. Personally Identifiable Information (PII) will be defined and the security requirements for this data clearly identified; Table 1 on page 12 of the Broad Agency Announcement (BAA) will serve as a starting point for identifying types of PII data. Strategies for system operations and data collection for evaluation will be defined with due consideration for protection of individual privacy. For example, evaluation data will be aggregated as early as possible, provided that the aggregation does not seriously degrade its value.

2. Proposed applications will need to exchange information with sensitive operational systems such as links to signal controllers, public transit dispatch systems, and traveler information systems. The SMOC will define the requirements associated with
these interfaces, developing the needed security architecture, and integrating this with the overall project architecture through the CVRIA.

3. The SMOC must also incorporate the security of the specific applications and the systems with which they must be integrated. This is especially important for the applications that involve public safety and safety of life considerations. The USDOT’s SCMS will be used for the applications that rely on DSRC communications to provide maximum protection for this safety-critical communication system. SCMS is designed to protect the security and privacy of data exchanged between vehicles and between vehicles and infrastructure. CV SCMS is a complex, advanced solution to provide trust and authentication via the incorporation of Security Certificates and Certificate Revocation Lists (CRL) into both existing and new infrastructure. The CVPD applications need to be designed such that the security management system will deliver the required Security Certificates and CRLs.

Given the direction that the standards process is taking in these areas, it is important to note here that it is expected that many, if not most, of these emerging security requirements (e.g., the future SAE J2945 standard) will be “built in” to vendor supplied hardware and software by the time that USDOT proceeds with Phase 2 of the CV Pilots program. Therefore, a key Phase 1 activity will be validating whether vendor technology that is anticipated to be available in Phase 2 will conform to these standards. As such, a major focus of the Phase 1 SMOC assessment will be to develop a SMOC validation plan and checklist that will be applied to candidate Phase 2 technologies.

The SMOC proposed for One California provides a unique opportunity to partner with FHWA to test security concepts in different settings, with different modes of transportation, and with different types of equipment across the three regions.

Task 4 – Safety Management Plan

While user acceptance of the new technology and the validation of expected benefits are vital to any deployment, the Team views safety considerations to be of paramount importance. New vehicle technology could introduce new risks and there is always the possibility that mistakes are introduced in the specification due to human error, malfunction, and/or unintended or malicious attacks that could impact the success of the CVPD and its outcomes.

This task includes two broad subtasks: identification of safety needs and development of a Safety Operational Concept (SOC). The One California concept includes a wide range of participants who could be system operators or consumers. This task will involve organizing and categorizing the mix of stakeholders, applications, participants, and field devices to identify safety risks and mitigating actions. The Team’s approach will look at each proposed application (grouped where appropriate), identify risks for each stage of application development and implementation, and determine how these may impact different groups (system operators, drivers, pedestrians, etc.). The SOC will directly address these risks and detail the mitigating actions that will be built into application development, testing, and operational activities. A program for ongoing monitoring during the CVPD also will be included, along with procedures for modifying the SOC as needed.
This task will also focus on the identification of risks and determine which FHWA risk mitigation strategies will reduce potential threats to the success of the Pilot Deployment. A high-level assessment, based on ISO 26262, will be conducted at the application bundle level to identify hazards, assess risks, and examine safety goals. Consistent with the USDOT Systems Engineering process, the results of this assessment will then be used to adjust the ConOps (Task 2) and contribute to the System Requirements (Task 6), as necessary. The implementation of a wide range of applications across different modes and different locations in the One California CVPD will help advance the state of knowledge regarding safety risks and mitigation techniques of the deployed applications.

**Task 5 – Performance Measurement and Evaluation Support Plan**

The measurement of performance is a central element of the One California proposal. The results will provide the information needed to: 1) assess the effectiveness of CVPD applications versus the goals, objectives, and transportation needs identified; 2) identify the impact of different environments and operational strategies on the effectiveness of the proposed applications (for example, transit signal priority and Queue Warning (Q-WARN) are being deployed in three regions and freight signal priority in two regions); and 3) identify lessons learned for wider deployment of those applications that are deemed successful. The One California approach will provide Caltrans, its partner agencies, and FHWA with an opportunity to look comprehensively at the effectiveness of applications across the State. While quantitative measures are most desirable, there are specific applications, such as Mobile Accessible Pedestrian Alert (PED-SIG) and Bus Stop Alert, where qualitative measures of user satisfaction will be useful.

To ensure that the CVPD produces the maximum contribution to knowledge about CV impacts on transportation system performance, the One California proposal links the key stages in system evaluation:

1. Defining performance measures that are identified at a high level in Task 2. An initial set of performance measures for all proposed applications is shown in Table I.1 and more detailed application descriptions are provided in Table III.1 of Volume I, Part III. These will be reviewed and refined during this task.

2. Determining how to record and archive measured data efficiently and with appropriate protection of confidentiality so that it can be used for subsequent analysis by the Independent Evaluator (IE), the regional partners, and the research community.

3. Determining how best to show the contrast between the performance measures with and without use of each of the CV applications (“before” and “after,” as well as selective activations of different combinations of features).
4. Determining how to account for uncontrollable external confounding factors in the archiving and preliminary analyses of the data, so that their presence or absence is well documented when the data are subjected to later analyses (making sure that differences in traffic associated with unusual weather conditions, public or school holidays, special events, labor disputes, severe incidents, etc. can be associated with these conditions rather than being incorrectly attributed to the presence or absence of the CV applications).

5. Defining how to convert the direct measurements from the CVPD operations into the higher-level system performance measures that are needed by decision-makers.

6. Identifying whether modeling and simulation tools will be needed to extrapolate from the limited-scale CVPD an estimate of the impacts that each CV application is likely to have at higher market penetrations and when deployed over larger areas. In this regard, safety benefits have been historically difficult to measure, and developing simulation approaches to forecast these benefits based on limited test data is an ongoing challenge. CV-specific simulation models are now emerging (e.g., TASS International’s Pre-Scan), which simulate all types of sensors, vehicles, vehicle-to-vehicle (V2V), and vehicle-to-infrastructure (V2I) technologies at a micro simulation-level. During Phase 1, the Team will develop approaches to using such models to estimate benefits, where feasible, based on limited pilot data.

7. Designing the means for efficiently disseminating periodic updates (daily, weekly, monthly) of the higher-level performance measures during Phase 3 of the project.

The Team plans to emphasize efficient design of the data collection system tailored to each application. Some applications, such as Probe-enabled Traffic Monitoring (PETM) will produce large amounts of data. Other applications, such as Bus Stop Alert, will be triggered by lower-frequency events and thus may require that quantitative data be supplemented with qualitative measures. Collection of PII will be minimized to the situations in which it is unavoidable so that the confidentiality protection requirements of the Institutional Review Board (IRB) only need to be applied to a minimum subset of the data (see Task 8 for the IRB discussion). In summary, the sampling and evaluation strategies need to be applied in the most efficient manner possible, and tailored to the goals, objectives, and data outputs of each application.

The Team already has experience with several of the CV applications that will be implemented for the CVPD, giving them a head start on understanding the most important data to collect for each one, as well as the limitations of what can be measured. METRO has deployed the FRATIS applications, as well as Wi-Fi-based transit signal priority. CA PATH has been developing the full set of MMITSS applications in prototype form along the El Camino Real corridor, as well as having developed and tested a prototype Q-WARN...
system under the SafeTrip-21 initiative. Caltrans and CE-CERT have tested the AERIS application in the Inland Empire region of Southern California.

For purposes of project planning and budgeting, Table I.1 identifies the principal sources of performance data for evaluation of the CV applications proposed by the Team:

**Table I.1 Overview of Data Sources for Performance Evaluation**

<table>
<thead>
<tr>
<th>Application</th>
<th>Practical Data Sources for Estimating Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Signal Priority</td>
<td>Fleet management systems; Local traffic and signal data</td>
</tr>
<tr>
<td>Freight Signal Priority</td>
<td>Fleet management systems; Local traffic and signal data</td>
</tr>
<tr>
<td>Mobile Accessible Pedestrian Signal System</td>
<td>Site survey; User survey</td>
</tr>
<tr>
<td>Freight-Specific Dynamic Travel Planning/Performance</td>
<td>Fleet management systems; Mobile application data</td>
</tr>
<tr>
<td>Drayage Optimization</td>
<td>Fleet management systems; Terminal management systems; Mobile application data</td>
</tr>
<tr>
<td>Dynamic Transit Operations</td>
<td>Operation control center data; Mobile application data</td>
</tr>
<tr>
<td>Bus Stop Alert</td>
<td>Site survey; User survey</td>
</tr>
<tr>
<td>Queue Warning</td>
<td>In-vehicle speed data from instrumented vehicles; Mobile application data</td>
</tr>
<tr>
<td>Dynamic Speed Harmonization</td>
<td>In-vehicle speed data from instrumented vehicles; Mobile application data</td>
</tr>
<tr>
<td>Eco-FRATIS</td>
<td>In-vehicle speed data from instrumented vehicles; Mobile application data</td>
</tr>
<tr>
<td>Eco-Smart Drive</td>
<td>Mobile application data; User survey</td>
</tr>
<tr>
<td>Pedestrian in Signalized Crosswalk</td>
<td>Site survey; User survey</td>
</tr>
<tr>
<td>Reduce Speed – Work Zone Warning</td>
<td>In-vehicle speed data from instrumented vehicles; Mobile application data</td>
</tr>
<tr>
<td>Curve Speed Warning</td>
<td>In-vehicle speed data from instrumented vehicles; Mobile application data</td>
</tr>
<tr>
<td>Probe-Enabled Traffic Monitoring</td>
<td>Probe data; Baseline detector data</td>
</tr>
<tr>
<td>Probe-Based Pavement Maintenance</td>
<td>Probe data; Maintenance records</td>
</tr>
</tbody>
</table>

The Team will prepare a Performance Measurement Plan in concert with its System Requirements Specification (SRS), including the following prescribed elements for each application:

- Participant action log;
- Data requirements for modeling and simulation usage;
- Data sharing framework;
- Identification of confounding factors;
- Field performance data collection with and without CVPD;
- Methods to generate use cases to show impacts;
- Data to support IE; and
Opportunities to leverage data from multiple applications (i.e., impact of signal priority applications, Transit Signal Priority (TSP) and Freight Signal Priority (FSP), on overall arterial operations).

When the Performance Measurement Plan is complete, the Team will present it in a webinar for interested internal and external stakeholders.

**Task 6 – Pilot Deployment System Requirements**

Building on the work completed in the ConOps and the other preceding tasks, the Team will prepare an SRS document, consistent with IEEE Standard 1233-1988. This SRS will:

1. be directly traceable to the ConOps (Task 2);
2. be informed by the recognized design constraints and configuration requirements;
3. clearly stipulate a set of specific, testable capabilities and performance measures (Task 5) that will represent and bound the system to be developed; and 4. be used to confirm that the system conforms to its intended purpose. Requirements will be traceable, demonstrating their relationship to specific, documented user needs. This will be accomplished through a formal traceability matrix process, as the example for the LA-Gateway FRATIS program in Figure I.5 demonstrates.

**Figure I.5 Sample Traceability Matrix Entry from the LA-FRATIS CV System Requirements Specification**

<table>
<thead>
<tr>
<th>Requirement ID</th>
<th>Requirement</th>
<th>User Need</th>
<th>Op Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSPR-1.0</td>
<td>FRATIS shall deliver current real-time information to users in less than 10 minutes (i.e., the data delivered to the user will be no more than 10 minutes old when delivered)</td>
<td>UN04</td>
<td>OS01, OS02, ...</td>
</tr>
</tbody>
</table>

Based on the experience of the Team in developing similar SRS documents on projects such as FRATIS, MTC’s 511 Program, the San Diego I-15 ICM, and numerous arterial signal corridor projects, the Team proposes a more comprehensive SRS approach than the minimum standard listed in the BAA. The SRS will encompass the following eight areas of system requirements:

- Functional requirements;
- External interface requirements;
- Internal interface requirements;
- Performance requirements;
- Security requirements;
- Privacy requirements;
- Data requirements; and
- Reliability requirements.

**Task 7 – Application Deployment Plan (ADP)**

As illustrated in Figure I.6, the Team understands the relationship between the CV application development and testing activities completed to date by USDOT, and how the CVPD program will provide the critical next steps in the maturation of these applications for deployment across the U.S. Moreover, the Team realizes that some applications are not as mature as others. For example, within the set of CV applications being addressed in the One California program, the Drayage Optimization (DO) application is fairly mature, with Open Source Applications Development Portal (OSADP) software available for download; in contrast, the PED-SIG application in the MMITSS program is only now
undergoing proof-of-concept testing. In recognizing this challenge, a unique feature of the Team’s ADP approach will be to estimate in the plan “levels of design tailoring” necessary to bring a given USDOT CV application up to the maturity level that will allow for successful final development and deployment in Phases 2 and 3 of the CVPD.

**Figure I.6 The One California CVPD in Relation to CV Applications Maturation**

One California’s ADP will describe in detail the implementation of One California physical architecture and will be traceable to the ConOps and Systems Requirements Documents – it is critical here that the applications address both the needs of the stakeholders/users and the FHWA objectives of the CVPD. The One California ADP document will cover the following ADP elements:

- Software (application and system);
- Hardware (roadside and vehicle);
- Communications;
- System interfaces;
- Hosted infrastructure;
- System integration;
- Procurement and installation;
- System testing;
- Operations, maintenance, and monitoring; and
- Data collection/support to IE Team.

Each CV application will be assessed in terms of these ADP elements and detailed estimates will be developed for the additional development costs needed to bring the applications into a deployment state during Phase 2.

The Team also recognizes the critical importance to USDOT of developing mature applications that can be “scaled” to other locations nationwide in the U.S. All CV application software developed by the Team will be open-source and will be made available to others using the OSADP/ITSforge.net site. In fact, members of the Team were partners in one of the first CV Dynamic Mobility Applications program software application bundles submitted to the OSADP under the LA-FRATIS program.

**Task 8 – Human Use Approval**

Human subjects use approval by an accredited IRB is required by Title 45 CFR Part 46.103 for any research obtaining data through intervention or interaction with a living individual where the data generated includes PII. The types of activities that require an IRB approval include interviews, surveys, and data collection involving systems intended
to alter the behavior of the subjects. In contrast, evaluations of the effectiveness of deployed systems, where there are no human subject interventions or interactions and no PII are generated, do not require an IRB review. The identification of IRB requirements in this task will build upon work conducted in Task 2 (ConOps), Task 3 (SMOC), and Task 5 (Performance Measurement and Evaluation Support Plan). The system effectiveness evaluations planned by One California for the TSP, FSP, Dynamic Transit Operations (T-DISP), Bus Stop Alert, PED-SIG, PETM, and Probe-Based Pavement Maintenance (PBPM) applications will not require IRB review, since these systems are not designed to systematically influence or test human behavior and the data collection will not include PII. If the Team determines that the evaluations of TSP, FSP, T-DISP, Bus Stop Alert, or PED-SIG require gathering user opinions, such as through a survey, then that activity will be submitted for IRB approval.

Other proposed applications, such as Q-WARN, Eco-FRATIS, Curve Speed Warning (CSW), and Reduce Speed – Work Zone Warning (RSWZW) are specifically intended to provide testable human subject interventions (in the form of an alert or instruction to the driver), and in these cases, both human subject interaction and the collection of PII will be required to evaluate the effectiveness of these applications. As an example, when vehicle-based data recording is used and the driver of the vehicle can be identified (e.g., through a vehicle log book), then IRB review and approval will be necessary. The IRB review will cover who is being recruited, how they are being recruited, informed consent, study procedures, and the protection of PII. In some of these cases, if the study can be designed such that an intervention is provided and behavior is recorded, but the data set is collected anonymously, the IRB review is still required, but typically an exemption will be granted.

CA PATH has been submitting ITS projects involving data collection on human subjects to the UC Berkeley Committee for the Protection of Human Subjects (CPHS) (Federal-wide Assurance #FWA00006252) over the past 15 years and that is the mechanism that is planned for IRB review in the proposed CVPD effort. In previous work under the SafeTrip-21 program, CA PATH coordinated the IRB review with the IEs from the Volpe Center, who needed to ensure that the guaranteed data protections would continue through the data analysis, providing a good precedent for IE coordination in the CVPD. For the CVPD applications that require IRB review to be implemented by this proposal, the Team will define the data collection protocols, develop the documentation required for IRB approval by the UC Berkeley CPHS, and perform the data collection and data archiving to ensure that the needed protections are observed.

**Task 9 – Participant Training and Stakeholder Education Plan**

Development of the Participant Training and Stakeholder Education Plan requires careful assessment of the educational needs of both the professional driver (freight and transit participants) and the nonprofessional users (motorists and pedestrians). In addition, agency and contract personnel involved in operations will need to understand both the overall One California project and the specific impacts on their operations.

Under this effort, the Team will develop a plan for how to engage and train participants on the project. The Team anticipates training several types of participants; pedestrians,
bicyclists, transit users, bus drivers, truck drivers, and light vehicle drivers. Operational personnel from signals, transit, freight dispatch, and other areas will need to be trained as well. The Team will provide these participants with instructions on the appropriate actions that must be taken for each of the messages they may receive.

The training effort will be coordinated with other activities, including meeting the IRB requirements and providing the needed input to the IE. The Team will design Background Questionnaires to collect data about drivers participating in the project for the purposes of data analysis and description by the IE. The Team will consult with the Contracting Officer’s Representative (COR) on the process of Office of Management and Budget (OMB) Information Collection Clearance related to developing the questionnaires and with the UC Berkeley CPHS for their approval.

Training will be tailored to the specific application and its user group(s). Users with cell phone-based applications will likely require less training than those with DSRC or other devices that are new to them. Training of professional drivers should reflect to the extent possible the practices of their employers and be consistent with applicable regulations. Part of the training will provide each participant with a clear understanding of USDOT’s Distracted Driving Policy. Training of transit, freight, and signal systems-related applications will be specifically tailored to those user groups.

The Participant Training and Stakeholder Education Plan will include, but will not be limited to, the following contents: One California CV Pilot program description, application descriptions, expected benefits, location information, type and number of participants by location, type of training, duration of training, schedule of training, forms and documentation, questionnaires, detailed instructions (both for trainer and trainee), operations and maintenance, and specialized training on using data collection devices.

**Task 10 – Partnership Coordination and Finalization**

The Team already has established a strong partnership and developed a Charter for the key agencies that will conduct the project. This agreement, which also is discussed in Volume I, Part II, covers the roles of the different partners, the governance of the agreement, and provides a structure for moving forward. The Charter already has established a Program Management Council, representing Caltrans, MTC, METRO, and SANDAG. In addition to these regional partners, numerous local cities, transit agencies, port authorities, and industry associations are supporting the Team, and Letters of Support from these will be made available to FHWA upon request.

In support of the USDOT’s AERIS program “Eco-Driving” applications development, CE-CERT has successfully planned and implemented CV application training methods on both public and private sector vehicle fleets. This involved testing a mobile Android driver feedback application in a field operational test on 15 private vehicles of the general public, 15 Caltrans pickup trucks, and 15 para-transit buses.

To both facilitate coordination, and to ensure that the applications are developed in response to real-world user needs, the Team will set up CV User Advisory Groups. These groups will start as a single group upon project initiation that will guide development of the ConOps, and then (as defined in the Task 2 ConOps) will branch out into multiple application-centric user groups that guide the Team in developing the System.
Requirements (Task 6), and review the Performance Measurement Plan (Task 5) and the Comprehensive Pilot Deployment Plan (CPDP) (Task 12). Furthermore, these groups will be utilized during the Phase 2 development, Phase 3 operations activities, and beyond. This unique feature of implementing sustained user groups for the life-cycle of this project will ensure systems engineering traceability of user requirements to CV applications; this will also support real-world and continued use of the Pilot system by stakeholders, which, in turn, allows the achievement of intended transportation system benefits as measured by the IE.

As part of partnership plan, the Team will build upon the Charter to develop agreements among Team members and among regional partners regarding the technical and operational details of applications deployment. This will ensure rapid development of the ConOps early in Phase 1, which will be critical to the success of this large program. Partnership Agreements will encompass the following areas:

- Governance and partner responsibilities, including changes in funding/finance and key personnel;
- Responsibility for equipment installation, monitoring, and maintenance;
- Training responsibilities and procedures;
- Cost-sharing responsibilities;
- Data approach, data collection methods, and approach for data sharing to One California and the IE;
- Initiation and scheduling of in-person meetings, including briefings, web site updates, and conference calls; and
- Outreach protocols for regional partners, including both public agencies and private parties.

**Task 11 – Outreach Plan**

As highlighted in Table I.2, a plan for the management of outreach activities will be developed in consultation with FHWA and the Team to enhance the stakeholder engagement process through oversight and guidance. Critical to the success of the CV Pilot project will be the ability to engage and sustain interest from a broad range of stakeholders. The Team already has demonstrated that they can establish strong relationships with stakeholder groups to guide transportation technology programs, including MTC’s 511.org, LA’s Arterial ITS Working Group, the LA port region’s Gateway Cities Goods Movements ITS Working Group, and SANDAG’s I-15 ICMS Corridor Working Group.
Table I.2 Outreach Plan Approach Overview

<table>
<thead>
<tr>
<th>Outreach Plan Goals</th>
<th>Work Elements</th>
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<tbody>
<tr>
<td>• Create public awareness of CV Pilot and generate stakeholder participation through a deliberative targeted outreach effort</td>
<td>• Plan to complete (and for CVPD staff to support) BAA-specifically defined annual outreach requirements: Press Conferences (2); Public Meetings (2); Industry Trade Articles (3); Workshops/Conferences/Trade Shows (3); and USDOT Webinars (2)</td>
</tr>
<tr>
<td>• Provide information to further public understanding of mobility, environment, and safety-related benefits as context for the CV Pilot</td>
<td>• Create PR/Marketing Plan/Media Strategy</td>
</tr>
<tr>
<td>• Promote understanding of how the CV Pilot fits into USDOT’s vision for connected transportation systems</td>
<td>• Develop key messages and themes for collateral materials</td>
</tr>
<tr>
<td>• Conduct knowledge and technology transfer to new adopters of CV deployment</td>
<td>• Conduct media relations</td>
</tr>
<tr>
<td>• Maximize the use of technology to reach an exponentially larger pool of participants</td>
<td>• Produce Outreach Video (develop two updates as project progresses)</td>
</tr>
<tr>
<td>• Leverage large user base of existing programs (511 users) to obtain participants</td>
<td>• Support FHWA with CV media events by supplying photographs and videos</td>
</tr>
<tr>
<td></td>
<td>• Engage in showcasing activities</td>
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</table>

The Outreach plan will include a Media Strategy for both local and national press, as well as a PR Marketing Plan for the development and delivery of collateral materials. Key aspects of the approach include:

- **Branding and Collateral** – Ensure that print and electronic materials communicate the CVPD’s vision and message in an effective and appealing way by using visualization (photos, illustrations, charts, etc.) and plain language.
- **Media Relations** – Raise awareness of the CVPD by using the media to reach a wide audience with key messages and identify local “champions” who can act as spokespeople for the project.
- **Web Site** – Provide on-line opportunities for the public to learn about the CVPD through unique web tools.
- **Target Audiences** – Target a diverse group of audiences, each of which may have different interests in the project.
- **Social Media** – Provide opportunities for ongoing public engagement in the CVPD through Facebook, Twitter, YouTube, and Flickr.
- **On-line Meetings** – Host on-line meetings and webinars to allow a greater number of people to participate remotely.

The Team will engage in showcasing activities about the CVPD projects and specific applications, write articles for transportation industry publications, and develop collateral materials. Media outreach includes press releases (both locally and nationally), a dedicated web site, promotional flyers, and fact sheets. The information disseminated will include methods for interested parties and organizations to get involved, methods to stay informed, and a calendar of deployment showcasing activities. There will be a specific
focus on creating curiosity and awareness in the CVPD areas to promote interest by local municipalities, businesses, and the general public. Support for FHWA with media events by supplying photographs and videos related to the CVPD also will be provided.

The Team will produce a video that illustrates a connected transportation system future and how CV technologies improve mobility, safety, and the environment in the CVPD regions. Animation and visual effects will be used to educate the viewer on the potential benefits of CV technologies.

Through the activities above, it is critical to develop a mechanism for feedback to determine the level of awareness of the CVPD among key stakeholder communities (freight, transit advocacy, technology sector), as well as the general public. The effectiveness of the materials and activities described will be evaluated by the One California Advisory Committee (see Volume I, Part II) at regular intervals to determine whether information is reaching target audiences and generating support for deployment across the State.

Task 12 – Comprehensive Pilot Deployment Plan

The CPDP will build on the ConOps and the previous tasks discussed in this proposal to provide a detailed “road map” for implementation and management of the three regions. Deployment of applications in multiple regions helps to provide important insights regarding operations under different conditions. For example, the LA region already has deployed TSP, which can provide an opportunity to deploy the application for both new and legacy systems.

Successful development of this plan will be critical to the success of the development and deployment of CV application packages in Phases 2 and 3. As the starting point for creating this plan, the Team will pull in all key findings and inputs from the previous 11 tasks, and in parallel, will involve all of the Task Leads, as well as key stakeholders and potential system users, in a two-day workshop. The workshop will spend Day 1 in a review mode, developing a consensus of the key inputs and findings from the previous tasks. Day 2 of the workshop will focus on developing the outline of the planning elements for the deployment plan – the outputs here will define the framework and technical activities necessary for the Team to complete the CPDP.

At a broad level, the CPDP will be constructed to achieve the following goals:

- Establish a data rich environment that supports real world CV applications;
- Enable pilot applications of CV technologies;
- Collect/store/report relevant data and share using Research Data Exchange (RDE);
- Advance the state of knowledge regarding the benefits of CV implementation;
- Advance integration of CV technology into State and regional planning;
- Create public awareness and determine user acceptance of CV technologies; and
- Create opportunities for commercialization/mainstreaming of CV technologies.

In order to achieve these goals, the Team is proposing the inclusion of a unique mix of vehicle fleets with intensive interactions in a real world environment that is most desirable for the CVPD Program. Moreover, as detailed in the project summaries presented in Volume II, Part
V, the Team has established CV Pilot applications above and beyond what is requested in the BAA, including deployments of AERIS and MMITSS described earlier in Part I. Furthermore, the Team has established a systematic approach that is both scientifically sound and practical for the collection of a rich set of data to support FHWA’s decision-making process.

The CPDP will be prepared to provide guidance and a common definition for the One California participants of the CVPD. The Plan will include detailed site planning information that identifies all Pilot elements and site information. It will also include hypotheses, data elements collected, and data formats and procedures for providing data to the IE. A summary of information to be included in the CPDP is provided in Table I.3.

**Table I.3 Information to be covered in the CPDP Document**

<table>
<thead>
<tr>
<th>Planning Information</th>
<th>Technical Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pilot participants and roles</td>
<td>• Experimental design</td>
</tr>
<tr>
<td>• Recruitment and training plans</td>
<td>• Performance standards by system, subsystem, and application</td>
</tr>
<tr>
<td>- Professional drivers</td>
<td>• Hypothesis of benefits</td>
</tr>
<tr>
<td>- Nonprofessional drivers</td>
<td>• Data Plan</td>
</tr>
<tr>
<td>- Alternate mode users</td>
<td>• Data needs</td>
</tr>
<tr>
<td>- Operating personnel</td>
<td>• Data format</td>
</tr>
<tr>
<td>• Specific description of deployment locations with maps and existing infrastructure</td>
<td>• Data transmission protocols</td>
</tr>
<tr>
<td>• Description of hardware and software components</td>
<td>• Data quality procedures</td>
</tr>
<tr>
<td>• Plans for equipment purchasing, testing, installation, operation, use, and removal</td>
<td>• Customer feedback and usability survey plan</td>
</tr>
<tr>
<td>• Acceptance plans and criteria</td>
<td>• Data sharing and archiving plan</td>
</tr>
<tr>
<td>• Pilot schedule for planning, purchasing, preparation, testing, and operation of equipment</td>
<td>• Monitoring and reporting plan</td>
</tr>
</tbody>
</table>

**Task 13 – Deployment Readiness Summary**

The Team will perform analysis of the components of the planned project that provide a measurement of deployment readiness. The analysis will review key technical and nontechnical challenges related to deployment and assess CV applications/technologies for their readiness to proceed with development activities in Phase 2. As such, a major input to this task will be the ADP (Task 7). The Task 7 results, in addition to the work on this task, will provide FHWA and the Team with a detailed understanding of the readiness of the applications, as well as for the overall concept framework.

The development of key agreements within a 12-month timeframe is a major challenge that the Team has met in the past, with projects such as I-15 ICM, MTC’s Urban Partnership Program, and FRATIS. The Team will utilize these experiences and identify success factors that can be applied to the CVPD. As discussed in the Task 10 approach, the Charter provides an excellent start in this regard.

During this task, the Team also will assess and fill gaps in regional ITS infrastructure to support CV operations. Along with public data, private ITS data feeds will be investigated,
which will require successful technical working relationships with select private sector agencies. A summary of both the technical readiness factors and the nontechnical readiness factors that will be assessed in this task is provided in Table I.4.

**Table I.4  Overview of Readiness Factors to be Assessed**

<table>
<thead>
<tr>
<th>Technical Readiness Factors</th>
<th>Non-Technical Readiness Factors</th>
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</thead>
<tbody>
<tr>
<td>• Clear identification of deployment locations, field device deployment, upgrades to existing signals, and communications networks.</td>
<td>• Coordination among stakeholders, including effective procedures for reporting and communications.</td>
</tr>
<tr>
<td>• Readiness of CVPD application users</td>
<td>• Scheduling and content for required stakeholder meetings and follow-up.</td>
</tr>
<tr>
<td>• Readiness of proposed One California applications, including required coordination between application developers, FHWA, One California, and operating stakeholders.</td>
<td>• Status of required operating agreements between stakeholders, including both One California team and regional stakeholders.</td>
</tr>
<tr>
<td>• Readiness of new equipment required for application functions (including vehicle integration)</td>
<td>• Status of privacy agreements, participant opt-in agreements, IRB reviews, and questionnaires.</td>
</tr>
<tr>
<td>• Data storage and management.</td>
<td>• Status of reporting and feedback procedures from system participants.</td>
</tr>
<tr>
<td>• Analytical and reporting tools for use in submitting progress reports and data to IE.</td>
<td>• Funding and personnel in place for deployment and ongoing operations and maintenance.</td>
</tr>
<tr>
<td>• Technology use to reach an exponentially larger pool of participants.</td>
<td></td>
</tr>
</tbody>
</table>

A readiness status report will be developed for each of the items identified above, along with any additional items identified through the risk management process.

**Phase 1 Deliverables**

All deliverables listed in Section J.4 of the BAA will be delivered to FHWA; the technical approach presented in this section has been specifically designed to develop all of these deliverables across the 13 tasks. Additionally, these deliverables will be delivered according to the dates listed in Section J.4. While One California presents recommendations in Volume I, Part III concerning some adjustments to the Phase 1 task dates, One California will meet all the final Phase completion dates as specified in Section J.4. Additionally, the technical approach provided here is designed to achieve full compliance with the FHWA “Performance Requirements Summary” in Section J.3.

**I.3  Primary Proposal Authors (in alphabetical order)**