San Francisco-Oakland Bay Bridge (SFOBB) Metering Lights System Upgrade Project

Systems Engineering Management Plan Framework

Prepared for:

BAY AREA TOLL AUTHORITY

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Table of Contents

1. Purpose **1**
1.1 Project Goals and Objectives **1**
2. SFOBB Metering Lights Background **3**
2.1 Current Organizational Structure **4**
2.2 Metering Lights System Upgrade Organizational Structure **5**
2.3 Project Scope **7**
2.4 Current Metering Lights System **7**
3. Technical Planning and Control **11**
3.1 Work Breakdown Structure **11**
3.2 High-Level Project Scope **12**
3.2.1 Project Subsystems *13*
3.3 Procurement Plan **13**
3.4 System Engineering Supporting Documents **13**
3.4.1 Risk Management Plan *13*
3.4.2 Concept of Operations/Needs Assessment *14*
3.4.3 Validation Plan *14*
3.4.4 System Requirements *14*
3.4.5 System Design *14*
3.4.6 System Integration Plan *15*
3.4.7 Verification Plan *15*
3.4.8 Performance Monitoring Plan *15*
3.4.9 Training Plan *15*
3.4.10 Operations and Maintenance Plan *15*
4. Systems Engineering Process **16**
4.1 Regional ITS Architecture **16**
4.2 System Requirements Analysis **16**
4.3 System Analysis **18**
4.4 Risk Management **18**
5. Transitioning Critical Technologies **20**
6. Integration of the System **21**
7. Integration of the Systems Engineering Effort **22**
8. Applicable Documents **23**

LIST OF ACRONYMS

ACTC	Alameda County Transportation Commission
BATA	Bay Area Toll Authority
CMS	Changeable Message Sign
CTC	California Transportation Commission
HOV	High Occupancy Vehicle
ML	Metering Lights
MPO	Metropolitan Planning Organization
MTC	Metropolican Transportation Commission
ORT	Open Road Tolling
SEMP	System Engineering Management Plan
SFOBB	San Fransisco-Oakland Bay Bridge
TMC	Transportation Management Center
WBS	Work Breakdown Structure

Document Control Panel				
Version No	Author	Reviewer	Submittal Date	Description
1	Phaneuf/Aguigui	Baker	9/24/2015	First Draft of SEMP Framework
2	Phaneuf/Aguigui	Baker	11/13/2015	Second Draft
3	Phaneuf/Aguigui	Baker	01/24/2016	Third draft updated with comments and revised diagrams
4				

1. PURPOSE

The Systems Engineering Management Plan (SEMP) describes the systems engineering effort needed in the planning for the upgrade of the San Francisco-Oakland Bay Bridge Metering Lights (SFOBB ML) System. This document will provide high-level guidance in managing the development of the project by identifying the items that are to be developed, delivered, integrated, installed, verified, and supported. Then, it will also identify when the tasks will be done, the parties involved, and how the system will be accepted and managed. Finally, the SFOBB ML SEMP defines the technical processes to be used to produce each project deliverable.

The SFOBB ML SEMP will be developed in a multi-step process, starting with the SEMP framework. The framework lays out the Systems Engineering process for the overall system, and includes the organizational structure, an overall schedule for system implementation, and identification of the technical tasks. Then, as each system is designed, the framework will be updated and supplied with the needed detail for each system. This will help in developing supporting plans needed in the final SEMP document.

1.1 Project Goals and Objectives

The planning for the SFOBB ML System upgrade will be focused on reducing queues and delays, improving travel times through the Toll Plaza and optimizing traffic flow across the Bay Bridge. The goal of the project is to improve traffic operations across the corridor and to have a adaptive metering system. Additionally, another goal of the project is to replace the current metering system which is antiquated and whose capabilities are limited.

The SFOBB ML project strategy was built upon an internal needs assessment developed by examining the existing system and discussing alternative approaches to the project delivery. The high-level needs of the project are:

- Implement an "adaptive" metering algorithm;
- Implement a fully automated system;
- Upgrade and replace existing system hardware;
- Design and upgrade associated network and detection systems as needed;
- Integrate the new system into the Caltrans ATMS; and
- Develop operational procedures for metering operations

These needs of the SFOBB ML System will build upon the current system's operation, which is being controlled manually from the Caltrans TMC. With the new system upgraded to a more automated system, it is anticipated that staff operations at the Caltrans TMC will need to be adjusted. Thus, there will be a need to develop a new set of procedures for monitoring and maintaining the SFOBB ML System once in place.

The project's goals are:

- Replace the existing metering lights system;
- Reduce queues and delays;
- Improve travel times;
- Optimize traffic flow across the Bay Bridge; and
- Improve TMC staff operations for the metering lights

2. SFOBB METERING LIGHTS BACKGROUND

The original metering system was deployed in 1974 and then was upgraded in 1980 using a Model 170 controller as the central minicomputer. Then, in 1990 the system was upgraded once more with an intention to utilize adaptive metering algorithms to more effectively adapt to changing conditions. The adaptive metering deployment was not successful and was replaced with essentially the same system that was originally deployed in 1980. In fact, most of the original system was reutilized in this replacement including the Model 170 controllers, the detectors, cabinets, lights, and communications system.

The current Toll Plaza has a total of 20 approach lanes including 16 toll booths, two open road tolling lanes (ORT), and two HOV lanes. During carpool hours, Toll Booths 1 and 2 are designated as HOV lanes only. In the current configuration, all of the approach lanes converge to 16 lanes at the existing metering lights, which is approximately 1000 feet west of the Toll Plaza. During the peak hours, only 12 lanes are controlled with the metering lights where the HOV lanes (four total lanes) are not metered.

The existing metering operations utilize a priority scheme for FasTrak users where FasTrak lanes are given shorter metering rates. This results in more FasTrak vehicles being released in comparison to cash paying vehicles. The figure below illustrates the current configuration of the Toll Booths and Metering Lights approaches.

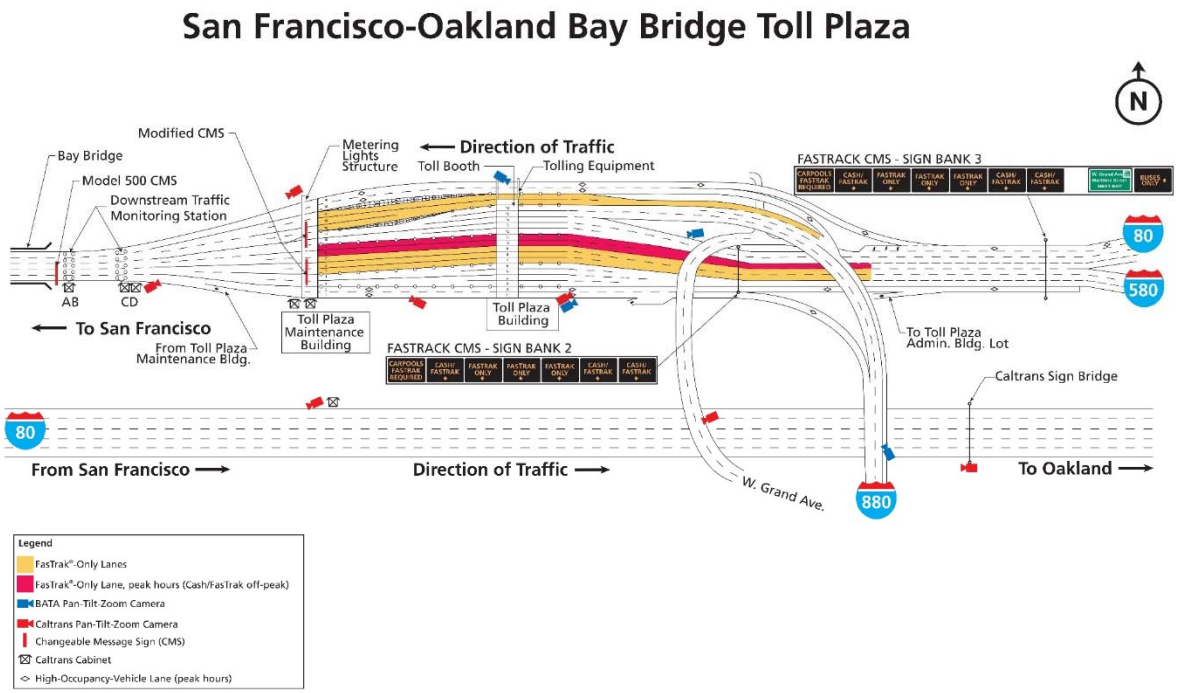
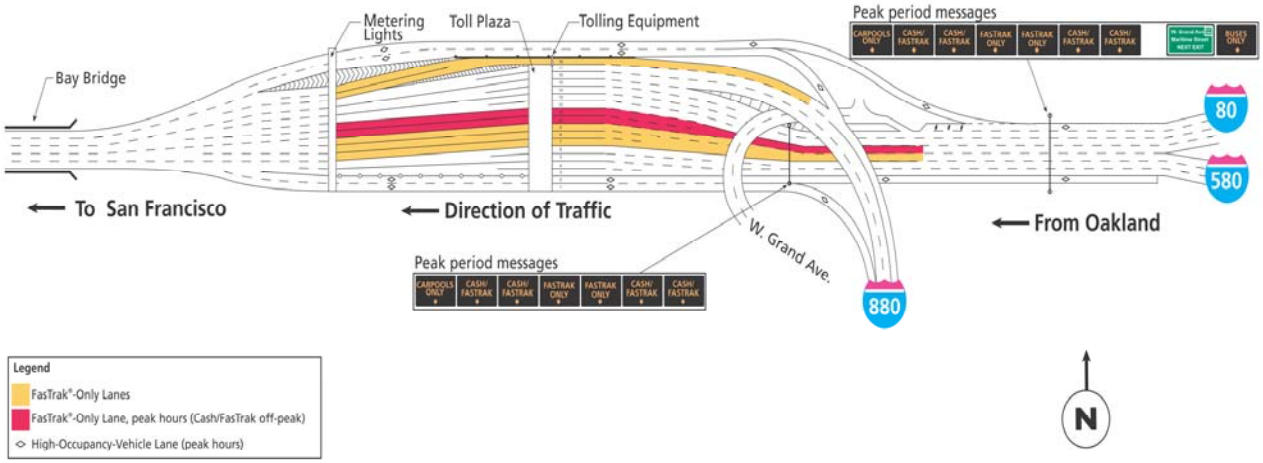


Figure 1 - Existing Conditions Diagram



The system was designed to operate in a fully automated mode, but tends to break down when there are incidents or other non-recurring events. In those incidences, the lack of data from detectors downstream from the metering lights means the system is not responsive to congestion. Currently, operators in the Caltrans TMC will adjust the metering lights based on observations from CCTV cameras in and around the metering lights and the foot of the Bay Bridge.

Because the system is mainly controlled manually today and most of the central equipment and field elements are old and antiquated, there is a need to replace most, if not all, of the central metering light elements and install a more automated and adaptive metering system that will not only improve traffic flow onto the Bay Bridge, but will result in more effective and efficient staff operations of the metering system at the Caltrans District 4 TMC.

2.1 Current Organizational Structure

The current organizational structure consists of the agencies that are involved in the existing operations of the metering light s system. These key stakeholders as follows:

Metropolitan Transportation Commission (MTC) is the transportation planning, financing and coordinating agency for the nine-county region in the Bay Area. MTC functions as both the regional transportation planning agency and as the region's metropolitan planning organization (MPO).

Bay Area Toll Authority (BATA) of MTC has the responsibilities of administration of toll revenue and joint oversight of the toll bridge construction program with Caltrans and the California Transportation Commission (CTC).

BATA currently funds day-to-day operations, facilities maintenance, and administration of the San Francisco-Oakland Bay Bridge as well as long-term capital improvement and rehabilitation of the bridge. The toll schedule for manual or electronic collection is established by BATA and the California Legislature. BATA is also responsible for the operation of the FasTrak Electronic Toll Collection program. BATA will contract with the appropriate firms to complete the project.

Caltrans owns, operates, and maintains the state-owned bridges and is responsible for day-to-day operations, maintenance and toll collection of the San Francisco-Oakland Bay Bridge. Caltrans will provide oversight of the design of the project.

BCDC has regulatory responsibility over development in San Francisco Bay and along the Bay's nine-county shoreline. It is guided by the McAteer-Petris Act, the San Francisco Bay Plan, and other plans for specific areas around the Bay. It is necessary to obtain a BCDC permit prior to undertaking most work in the Bay or within 100 feet of the shoreline, including filling, dredging, shoreline development and other work.

California Highway Patrol (CHP) is responsible for the enforcement of the Bay Bridge and State Highway assets. It is anticipate that they will be a stakeholder in the system design.

2.2 Metering Lights System Upgrade Organizational Structure

For the planning, design and delivery of the upgraded SFOBB ML System, the following are the key stakeholders and their roles and responsibilities. A draft project organizational chart is provided in Appendix A.

Kimley-Horn performs the role of the Project Manager and System Designer. It is responsible for developing/monitoring a comprehensive work plan at the project scoping that includes a list of project tasks, scheduling requirements, staffing requirements, and equipment and material requirements necessary to complete the scope of work tasks on time and within budget. The work plan will be continually monitored and revised as the project proceeds to meet time and budget constraints. It is also responsible for providing guidance on technical issues/topics, and reviewing deliverables/conducting testing. Kimley-Horn will develop the initial set of design plans to be used for procuring the construction contractor. The design plans will be completed by the Construction Contractor and the Systems Integrator.

HDR will provide environmental support for BATA and Caltrans including a review of environmental constraints information available for the project area as well as a review of pertinent state and federal regulations, policy, and guidance. HDR will help develop an environmental and permitting strategy for the project based on the sensitive environmental resources in the area of the proposed design.

BATA will be responsible for procurement of a Systems Integrator as a professional service. The Systems Integrator will provide input on the design of the construction plans and will also design, develop, implement, and test the metering lights system.

BATA will be responsible for procurement of a Construction Contractor for the completion of the design plans, the installation of field elements including conduits, pull boxes, cabinets, signal heads, poles, conductors, and any other field elements for the metering lights system upgrade.

Caltrans will provide oversight and technical assistance on the scoping of the project. They will also provide design reviews and will issue the construction permit for the civil elements of the new system. They will also provide oversight working closely with the System Integrator during the implementation of the new system.

Federal Highways Administration (FHWA) will provide technical assistance as requested by BATA.

BATA and Caltrans Project Working Group includes staff members from both organizations responsible for the project development and delivery

Executive Project Steering Committee includes executive management team members from both organizations responsible for overall project direction.

Alameda County Transportation Commission (ACTC) as the Congestion Management Agency is deploying an Integrated Corridor Mobility (ICM) system along I-80 which directly feeds the Bay Bridge. Their involvement will be for the most part focused on the interaction between the I-80 ICM and the SFOBB ML Systems.

System Integrator will be responsible for the delivery and implementation of the upgraded SFOBB ML System including the central hardware and software.

The figure below represents a high level view of the overall organization of the key stakeholders. A more detailed stakeholder organization chart is provided in Appendix B.

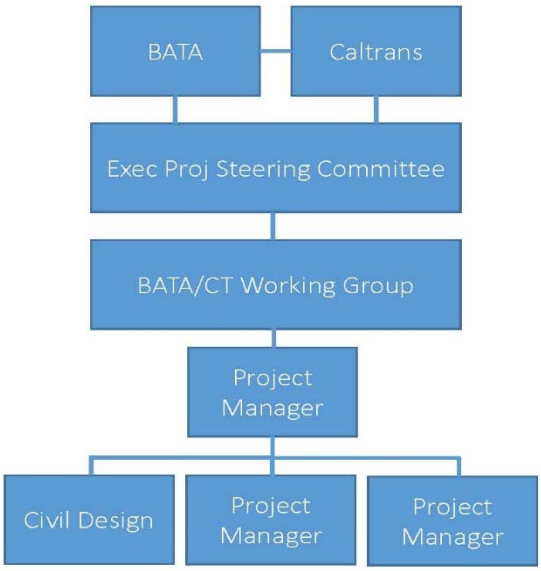
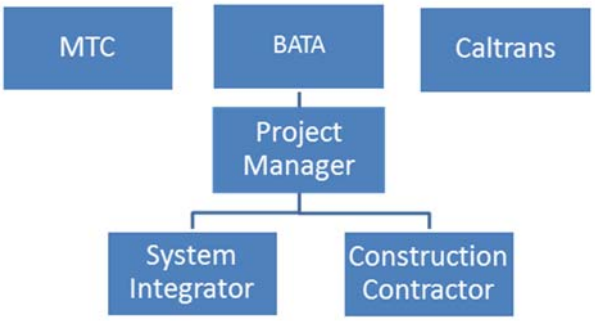


Figure 2 - Project Organizational Chart



2.3 Project Scope

The SFOBB ML Upgrade project will upgrade the metering lights system and associated field and central system equipment. It will provide for redundancy of the system in the event of an emergency. The new SFOBB ML System will be integrated into the existing Caltrans ATMS. It will also replace existing Changeable Message Signs located on the metering lights structure. It will repair or close existing gaps in the communication system and repair or enhance existing detection as needed for an automated and adaptive metering system.

The new SFOBB ML System will integrate existing traffic monitoring stations in the vicinity of the Toll Plaza to respond to traffic both upstream and downstream of the Toll Plaza. It is expected to be customized software system.

2.4 Current Metering Lights System

The existing metering lights systems consists of several elements including:

- Field Controllers
- Metering Lights
- Loops
- Changeable Message Signs
- Communications
- Central Systems (Metering Server and ATMS)

Each of these are described below. The figure below provides a high level system diagram of the existing metering lights system.

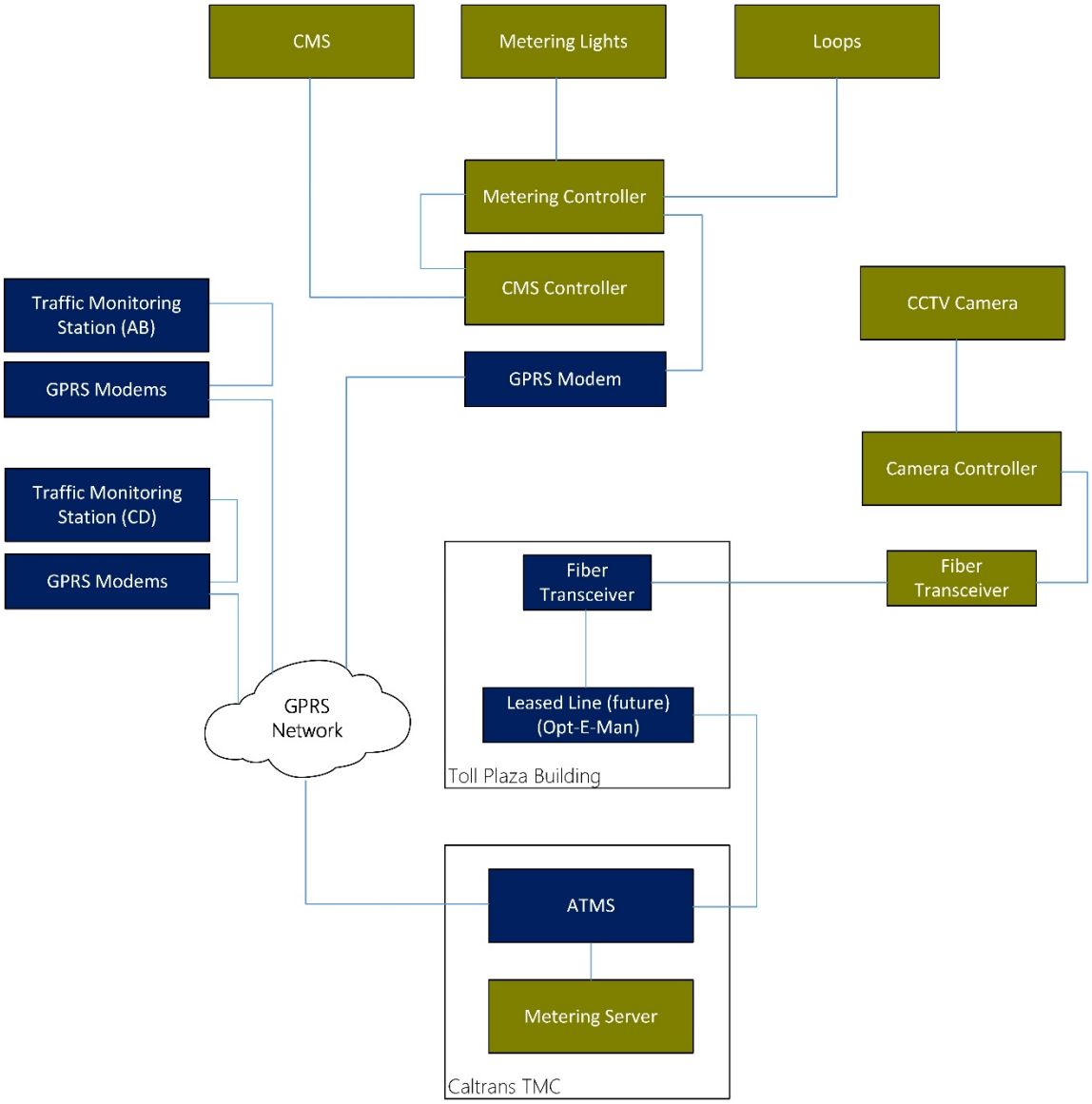


Figure 3- Existing System Diagram

Field Controllers and Cabinets

There is a modified Type 332 cabinet near the metering structure that houses the metering controller. This controller is responsible for receiving calls from the detectors on the approach lanes to the metering lights and receiving commands from the metering lights central system to turn on and implement different metering rates.

There are two Traffic Monitoring Stations (TMS) that consist of Type 332 controller cabinets. One of the cabinets is at the foot of the bridge incline (designated "AB"), and one at the start of

the 5-lane sections closer to the toll plaza (designated "CD"). The AB and CD cabinets house the Model 170 controller used for loop detection at these locations.

Changeable Message Signs

There are two existing CMS (7488 BB) mounted on the metering lights structure that are intended to display the message "PREPARE TO STOP" in advance of the metering lights going on. The signs are triggered by an electrical signal from the metering controller. The connection between the CMS controller and the metering controller is a type of electrical conductor. The CMS have their own cabinet (356 BB). The CMS are not functioning at this time.

Communications

Currently the AB, CD, and metering controller cabinets connect back to the Caltrans TMC via a leased wireless connection. There is a wireless modem in each of the three cabinets. In addition, there is an existing single mode fiber cable between the AB and CD cabinets and the Toll Plaza Administration building.

There is also an existing multimode fiber cable between the metering controller cabinet and the Toll Plaza Administration building. The fiber cable is in place, but it is not being used for communications with no data being exchanged. The fiber eventually ties into a leased line circuit in the Toll Plaza Administration building.

Central Systems

The central metering system software is an independent system that operates on the same work station as the Caltrans ATMS in the Caltrans District 4 TMC. The central metering software is also installed on a backup work station at the TMC that is independent from the ATMS network. In the event there is a major system failure where the Caltrans TMC loses communications to the metering controller, the metering system must be operated from the metering controller in the field.

The system is manually operated using command response to assist with the merging of 16 travel lanes to 5 travel lanes. The existing commands are:

- Time of Day,
- Manual Operations, and
- TMC Operations.

A metering sequence table, which is an Excel spreadsheet, is used to determine the metering rate for each lane with priority given to FasTrak lanes. The metering sequence table provides the algorithm for each of the lanes taking into account lane adjacency so that adjacent and second adjacent lanes are not given a "green" signal at the same time. The Bay Bridge ramp meters are operated 7 days a week. The meters are activated based on Bay Bridge queuing, at

approximately the same time daily for weekday and weekend peaks. The operators can adjust the metering rates from between 40 to 199 vehicles per minute (vpm) and use the metering sequence table to adjust the allocation between the FasTrak and cash lanes. Currently, the ramp metering system only uses occupancy data as an input into the system.

ATMS

The Caltrans Advanced Transportation Management System (ATMS) provides real time information about Caltrans assets. The ATMS provides data on individual lane occupancy, flow, average speed, and system status. It also has a connection to the CHP Computer Aided Dispatch (CAD), which provides incident data. Ramp metering operators use CAD data to assist with ramp metering operations in the even there is an incident that effects the Bridge or the merge area. The ATMS is not directly integrated into the ramp metering system, but the two systems coexist on the same network.

3. TECHNICAL PLANNING AND CONTROL

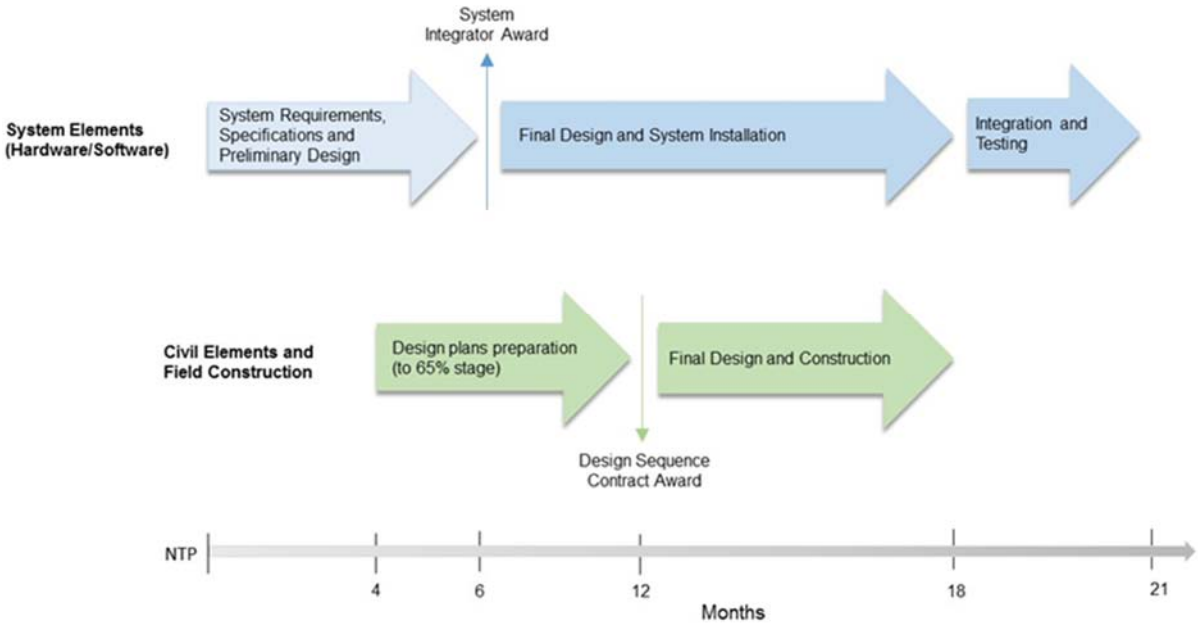
The SFOBB ML System will be designed, integrated, and deployed according to the Systems Engineering process required for federally funded ITS projects. The following sections describe the anticipated plans and activities that serve as controls for the project's systems engineering activities.

3.1 Work Breakdown Structure

The Work Breakdown Structure (WBS) is a list of all tasks to be performed on the project. The WBS breaks down the tasks into individually budgeted items. The draft project schedule provides detailed tasks and deliverables is attached in Appendix C.

A high level process of the project approach and relationships between tasks is provided in the figure below. The approach to project delivery will be a split approach to the system elements and the field elements with Caltrans and BATA oversight as shown in the figure below.

The System Design will prepare the requirements, specification, and preliminary design of the entire system. The System Integrator will be selected by a Request for Proposals during the civil design phase. The System Integrator will provide input into the design of the field elements and will complete the final design and integration of the ramp metering system and metering algorithm. At the 65% design phase, a Construction Contractor will be selected using a design sequence/construction manager general contractor award. The Construction Contractor will provide input into the design and construct the improvements. Finally, the System Integrator will test the metering system. A detailed WBS will be prepared with the detailed project schedule.



3.2 High-Level Project Scope

The SFOBB Ramp Metering Lights Upgrade project will upgrade the metering lights system and associated traffic controllers. It will provide for redundancy of the system in the event of an emergency. The project will integrate the metering lights system into the Caltrans ATMS. It will also replace existing Changeable Message Signs at the metering lights. It will repair or close communication gaps and repair or enhance detection for a adaptive metering system. They system will integrate the ramp metering detection and the corridor-wide system to respond to traffic both upstream and downstream of the toll plaza. It is expected to be customized software system owned by BATA with a warranty and maintenance agreement.

The SFOBB ML System design will consist of the following:

- System Architecture development
- System requirements development
- Metering Algorithm inputs and constraints
- Systems Engineering Documentation
- System Design
- Systems Integration Plan
- Civil Design
- Network Security and Failure Requirements
- GUI Requirements
- Metering Requirements
- Testing Plan
- Integration Testing
- Acceptance Testing

The System Design elements include:

- Repair/calibrate the existing detection on the bridge (east span, westbound)
- Upgrade existing metering equipment communications to use IP-based communications
- Upgrade existing metering cabinets and controllers
- Modifications to the existing office space to accommodate the backup system at the Toll Plaza
- New changeable message signs on the metering lights structure
- Additional CCTV cameras for monitoring the merge area and bridge approaches

- Detection repair and connections on the west span, westbound approach with the assumption that additional detection on the bridge approaches is not needed.

3.2.1 Project Subsystems

The SFOBB ML System and subsystems are described below. As the project evolves, the proposed System Architecture will be updated.

Caltrans ATMS – The Caltrans ATMS is the central system for District 4 to control and monitor Caltrans field elements. It is used to monitor and respond to incidents and events. The Ramp Metering System will be integrated into the Caltrans ATMS. The proposed CMS for the metering lights will be integrated into the ATMS.

New SFOBB ML System – The SFOBB ML System will control the metering lights. The ML System will use data from mainline detectors and customized algorithms that will allow lane-by-lane control of the metering lights. The SFOBB ML System will be able to be viewed and operated independent of the ATMS.

Existing SFOBB ML System – The existing system will continue to operate in parallel with the new metering system through the testing and acceptance testing phase. Once the new system has been fully tested and accepted and after the initial burn-in period, the existing metering system will be retired.

Mainline Detection System – The Mainline Detection System is monitored through the Caltrans ATMS. It will provide volume and occupancy data to the SFOBB ML System upstream and downstream of the metering lights.

Metering Lights Detection System – The ML Detection System provides call and passage detection for vehicles at the stop bar of the metering lights. These detectors provide the actuation for the metering lights. In is anticipated that the metering lights detection and mainline detection will provide the data inputs to the SFOBB ML System as part of an updated metering algorithm.

3.3 Procurement Plan

Kimley-Horn is working with BATA to develop procurement documents for the new system. The new SFOBB ML System will consist of central system hardware and software, as well as ITS field communications and field devices to support the system. The SFOBB ML project will be managed and administered by BATA through construction and systems acceptance, at which point it will be handed over to Caltrans for operations and maintenance. The Procurement Strategy Memo is shown in Appendix D which presents the preferred procurement approach.

3.4 System Engineering Supporting Documents

The following documents will be prepared as part of the Systems Engineering process.

3.4.1 Risk Management Plan

The System Integrator will develop a Risk Management Plan to identify the risks of system development because of the number of inputs, data sources, and amount of integration

required. The Risk Management Plan will assess the magnitude of the risks and identify mitigation measures where necessary. A Risk Register will be prepared to support the Risk Management Plan. The Risk Register will identify the risks, the impact, priority and mitigation measures.

3.4.2 Concept of Operations/Needs Assessment

The Concept of Operations will include the development of Operational Scenarios. Some of the key operational scenarios that will be developed include:

- Normal traffic operations – weekdays and weekends
- Freeway incident affecting Bay Bridge and/or Toll Plaza operations
- Real-time and automated management of recurring and non-recurring congestion
- Emergency situation impacts to Bay Bridge and Toll Plaza operations
- Data collection and evaluation on the system for performance monitoring of traffic flow, metering rates, or field operating conditions including metering tables that set priorities for FasTrak ® users.

Kimley-Horn will prepare a comprehensive outline for the Concept of Operations prior to commencing with the full document preparation. The proposed system's architecture will be included in the Concept of Operations.

A workshop for stakeholders is anticipated to flush out the operational scenarios and high level requirements for the new SFOBB ML System. BATA and Caltrans will oversee the development and approve the Concept of Operations.

3.4.3 Validation Plan

The Validation Plan will be prepared with the Concept of Operations and will identify the activities that are necessary to "validate" the Concept of Operations of the metering system based on the user needs and operational scenarios. A metering system validation will be conducted according to the Validation Plan. BATA, with Caltrans oversight will approve the Validation Plan.

3.4.4 System Requirements

The System Requirements will be prepared as single set of requirements with separate sections relating to different elements of the metering lights system. The Requirements will be divided into General, User, Technical, and Operational Requirements. BATA and Caltrans will oversee the development and approve the System Requirements.

3.4.5 System Design

The System Design will define the organization, structure, facilities, tools and processes to be used to produce the project's software and hardware for the ramp metering system, as well as possible ITS communication and field devices to support the system. BATA and Caltrans will oversee the development of, and approve the System Design. For the Civil

Design elements, Caltrans will conduct the reviews and approve the design which is expected to be an encroachment permit.

3.4.6 System Integration Plan

The System Integration Plan will define the subsystems and data sources for the new system. It will also include the system integration schedule, dependencies, and integration methods to be performed by the System Integrator. The System Integration Plan will provide details on the elements to be integrated under the proposed system architecture (to be developed with the Concept of Operations), and will include any phased implementation of features and functionalities of the new SFOBB ML System. BATA and Caltrans will oversee the development and approve the System Integration Plan.

3.4.7 Verification Plan

A Verification Plan associated with the System Requirements will be prepared to describe the activities associated with verifying that the new metering lights system satisfies all the system requirements. A metering system verification will be conducted according to the Verification Plan. BATA and Caltrans will oversee the development and approve the Verification Plan.

3.4.8 Performance Monitoring Plan

A Performance Monitoring Plan will be used to track the success of the project in meeting the overall project goals. In addition a Performance Reporting Plan will identify goals and objectives and include the key performance measures to collect and assess for the upgraded system. The plan will include a schedule for ongoing data collection and reporting.

3.4.9 Training Plan

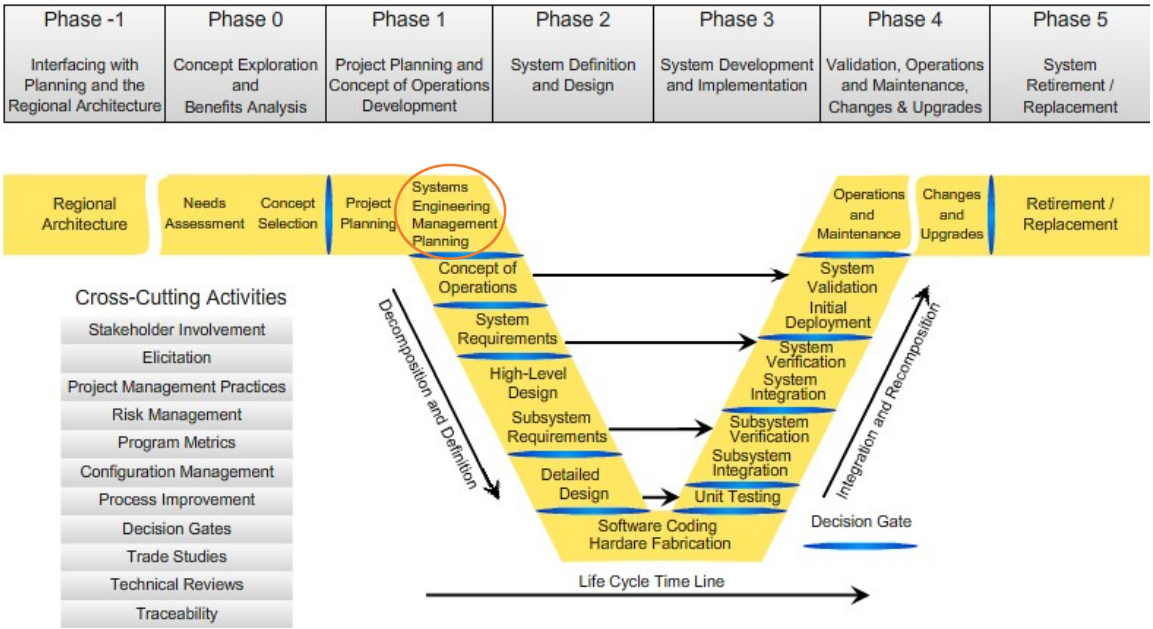
A Training Plan will be developed to train Caltrans on the operations and maintenance of the New Ramp Metering System. It will include documentation, as well as in person training sessions, with videos or webinars that can be accessed on-demand.

3.4.10 Operations and Maintenance Plan

An Operations and Maintenance Plan will be completed for the SFOBB ML System including any new elements and subsystems. It will also include the metering lights operations at the District 4 TMC and the backup systems. Lastly, it will define the operations and maintenance functions and responsible party. BATA and Caltrans will review and approve the Operations and Maintenance Plan.

4. Systems Engineering Process

This section describes the activities and plans that act as controls on the project's engineering activities. Under the FHWA's Final Rule [23 CFR Part 940 part 11], systems engineering analysis is required for projects funded with highway trust funds. The development and implementation of the metering lights system will follow the systems engineering process shown in the figure below. The red circle indicates where the SEMP fits in the overall project development lifecycle.



Systems Engineering Process

4.1 Regional ITS Architecture

The SFOBB project is consistent with the Bay Area ITS Architecture and implements the following service package:

- ATMS01 - Network Surveillance
- ATMS04 - Traffic Metering
- ATMS05 - HOV Lane Management
- ATMS06 - Traffic Information Dissemination
- ATMS10 - Electronic Toll Collection

MTC and Caltrans are included as stakeholders in the Architecture.

4.2 System Requirements Analysis

The System Requirements will be identified and developed through the following steps:

- Draft ConOps will be developed for the metering lights system upgrade. The Draft ConOps will address/identify/confirm stakeholders, needs, and expectations; the vision of what the system upgrade will do; and how the system will operate, under what environment, and how it will be supported. The ConOps will discuss the system from the perspective of multiple users/stakeholders/systems. A workshop will be conducted with the stakeholders to flesh out the needs and operational scenarios and high level requirements for metering lights. Additionally, TMC staff interviews will be conducted along with observations of metering operations and the existing and desired logic for the new system.

- Draft System Requirements will be derived from the Concept of Operations. This will document the technical elements that will be carried out to meet the needs identified in the draft ConOps. These requirements will be developed through meetings with BATA and Caltrans and will include, but not be limited to, the following elements:

    - Field Controllers;
    - Cabinets;
    - Metering System;
    - Control Logic;
    - Central System Integration;
    - Detection;
    - CCTV Cameras;
    - Signal Heads; and
    - Communications System.

- The requirements will be divided into General, User, Technical, and Operational Requirements and the following elements will be covered, at a minimum:

    - Metering Control Logic - Automated and adaptive operations; dynamic adjustment of rates; rates based on usage priorities (e.g., for FasTrak ® vehicles, or HOV); downstream merging; manual/override control; AET; etc.
    - Detectors and Detector Failures - Accuracy; Maintenance; Alerts to user-specified recipients; Logging; etc.
    - Communications and Communication Failures – IP-based; Standards-based; Alerts to user-specified recipients; Logging; etc.
    - Reporting - Logs; Queries; Alterations; Users

4.3 System Analysis

The upgraded SFOBB ML System will be developed using a Systems Engineering process. The system will be designed using a defined requirements to limit the alternatives. In the event that a trade-off analysis or alternatives analysis needs to take place, BATA will review the cost and schedule impacts with relation to the benefit to the users or the stated goals of the project.

4.4 Risk Management

The SFOBB ML Upgrade Project is a high risk project because of the critical nature of the system to regional traffic operations, the number of stakeholders, and the integration of multiple systems. The SEMP will continue to identify and assess sources of risk throughout the design, development, and integration of the SFOBB ML Upgrade project. The Risk Management Plan will outline how risk management will be performed, including determine if a newly identified risk has an impact on the requirements. The following table highlights some of the currently identified risks. A comprehensive Risk Register will be prepared with the Risk Management Plan. Once prepared, the Risk Register will be maintained over the course of the project.

Risk Number	Possible Risk	Risk Description	Probability (1-10)	Impact (1-10)	Risk Factor (1-100)	Mitigation Process
1	Schedule Conflicts and Slippage	The implementation of the metering system involves the coordination of multiple contractors with many interdependencies. The coordination of the schedule and the conflicts between schedules are a source of risk. The schedule may slip because of unknowns in software customization or construction issues.	9	10	90	BATA and the Project Manager will manage a master schedule for all of the Contracts and Activities. Critical path will be clearly defined including time for Caltrans processes. In addition, the schedule will be re-examined to determine what items can be taken off of the critical path if more time is needed for development. BATA will work with Caltrans to identify ways to mitigate schedule risk by shortening review periods or fastracking approvals.

Risk Number	Possible Risk	Risk Description	Probability (1-10)	Impact (1-10)	Risk Factor (1-100)	Mitigation Process
2	Conflict between Contractors	Disagreement or conflict on scope, schedule and/or allocation of budget	5	5	25	BATA and the Project Manager will clearly define the scope and limits for each Contractor. BATA will manage the process and resolve conflicts. BATA will amend contracts if necessary.
3	Integration Issues	There are risks to integrating the new Ramp Metering System with the existing Caltrans ATMS. These risks may impact schedule and scope	5	8	40	BATA and Caltrans will work closely with the System Integrator to identify any technical challenges and a mitigation approach. If necessary, BATA and the Program Manager will identify an alternate approach.
4	Data Quality	There is a risk that the new Ramp Metering Algorithm will underperform because of poor data inputs.	1	7	7	The System Integrator will provide input into the design in order to mitigate the risk of poor data quality. This risk is minimal. In the event it occurs, the Contractors will work together to solve the issues and an appropriate change order will be initiated.

5. TRANSITIONING CRITICAL TECHNOLOGIES

The SFOBB ML System is a critical system for the Bay Area. The existing system has long passed its useful life and has reached a point where operations rely on manual intervention. The upgrade of the metering lights system will improve operations and be more responsive to traffic conditions, and will rely on customized software due to the uniqueness of the facility and the needs of the system, i.e., it is not expected that any off-the-shelf software and system will be able handle the needs of the SFOBB ML System without customizations and added capabilities.

Because of the unique nature of the bridge approach conditions with the number of lanes and lane transitions, the different priorities between HOV, Fastrak and ORT lanes, data inputs, and integration with existing system, there will be a substantial transitioning of old technology to newer technologies. The risks for integration of new data sources or other technology transitions will be discussed in the Risk Mitigation Plan or the Integration Plan.

6. INTEGRATION OF THE SYSTEM

This section describes the methods to be used to integrate the developed components into a functional metering lights system. The System Integrator will have the responsibility to integrate the functionality of the existing metering lights system including the new metering algorithm with the existing ATMS.

The new SFOBB ML System will integrate existing and proposed detector speed and occupancy data from the Caltrans ATMS to detect the presence of vehicles and queuing upstream and downstream of the metering lights. The new system will also have the ability to provide lane-by-lane priority based on an "adaptive" algorithm operating under continuously changing traffic conditions and/or HOV/FasTrak/Passenger Vehicle lane classifications.

The integration of the system will follow the Systems Engineering process for verification, validation, deployment, and operations and maintenance of the various subsystems. A System Integration Plan will be developed by the System Integrator which will contain approaches, processes and methodologies for the following at a minimum:

- Existing hardware, software, systems, subsystem and data to be integrated;
- Support environment for integration during system testing and final acceptance;
- Phasing the integration of system elements for testing and implementation;
- Integration activities between existing systems from other stakeholders (e.g., ATMS); and
- Security measures to be implemented during the integration of the system.

7. INTEGRATION OF THE SYSTEMS ENGINEERING EFFORT

The Systems Engineering effort will be led by BATA and the Consultant Project Management Team. BATA will be responsible for reviewing the deliverables and managing the Systems Engineering tasks. The SEMP will be completed by the selected System Integrator. Caltrans will provide oversight, technical support, and review of the Systems Engineering effort. The design of each of the subsystems will be completed by the system designers under contract to BATA. BATA, Caltrans and the Project Management Team will oversee the testing, validation, and verification of each of the subsystems.

Caltrans, BATA, and the Project Management Team will work in close coordination as a team to complete the Systems Engineering efforts. There will be weekly team meetings and on-going action item lists to identify critical path items. The table below outlines the responsible party for the different deliverables under the Systems Engineering effort.

System Engineering Task	Responsible Party
SEMP Framework	Kimley-Horn complete; BATA review
SEMP	System Integrator complete; Kimley-Horn & BATA review
Concept of Operations	Kimley-Horn complete; BATA & Caltrans review
System Requirements	Kimley-Horn complete; BATA & Caltrans review; System Integrator provide input
System Design	System Integrator complete; Kimley-Horn, Caltrans, & BATA review
Field Element Design	Kimley-Horn complete; BATA & Caltrans review; System Integrator provide input
Testing, Verification, Validation	System Integrator complete; Kimley-Horn, Caltrans, & BATA review

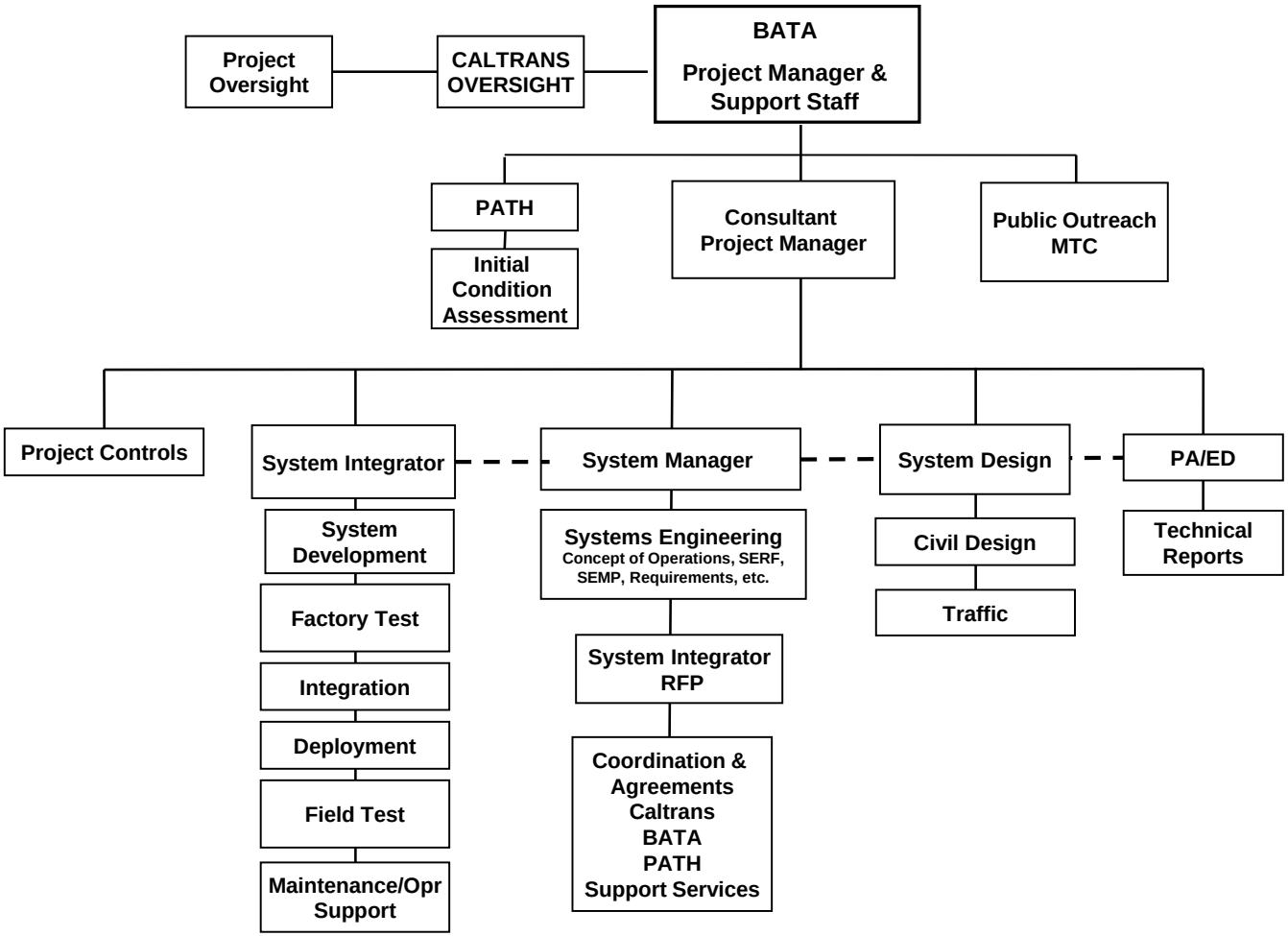
8. APPLICABLE DOCUMENTS

The applicable documents for the SEMP will be updated as the Systems Engineering process continues. The applicable documents are:

- Project Development Schedule
- Existing System Architecture
- Concept of Operations
- High-Level Requirements
- Others to be defined

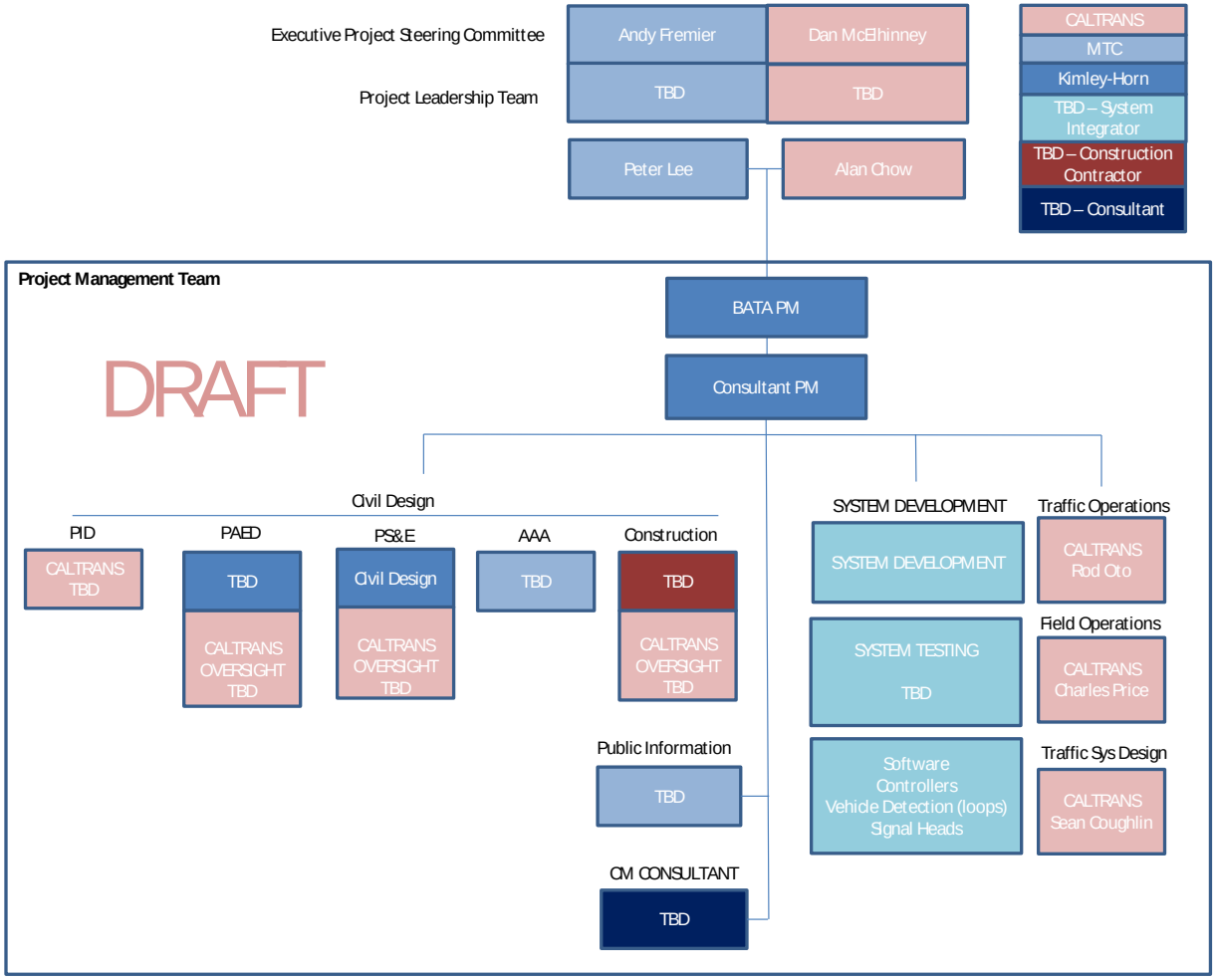
APPENDIX A – PROJECT ORGANIZATIONAL CHART

SFOBB ML System Upgrade – Project Organizational Chart



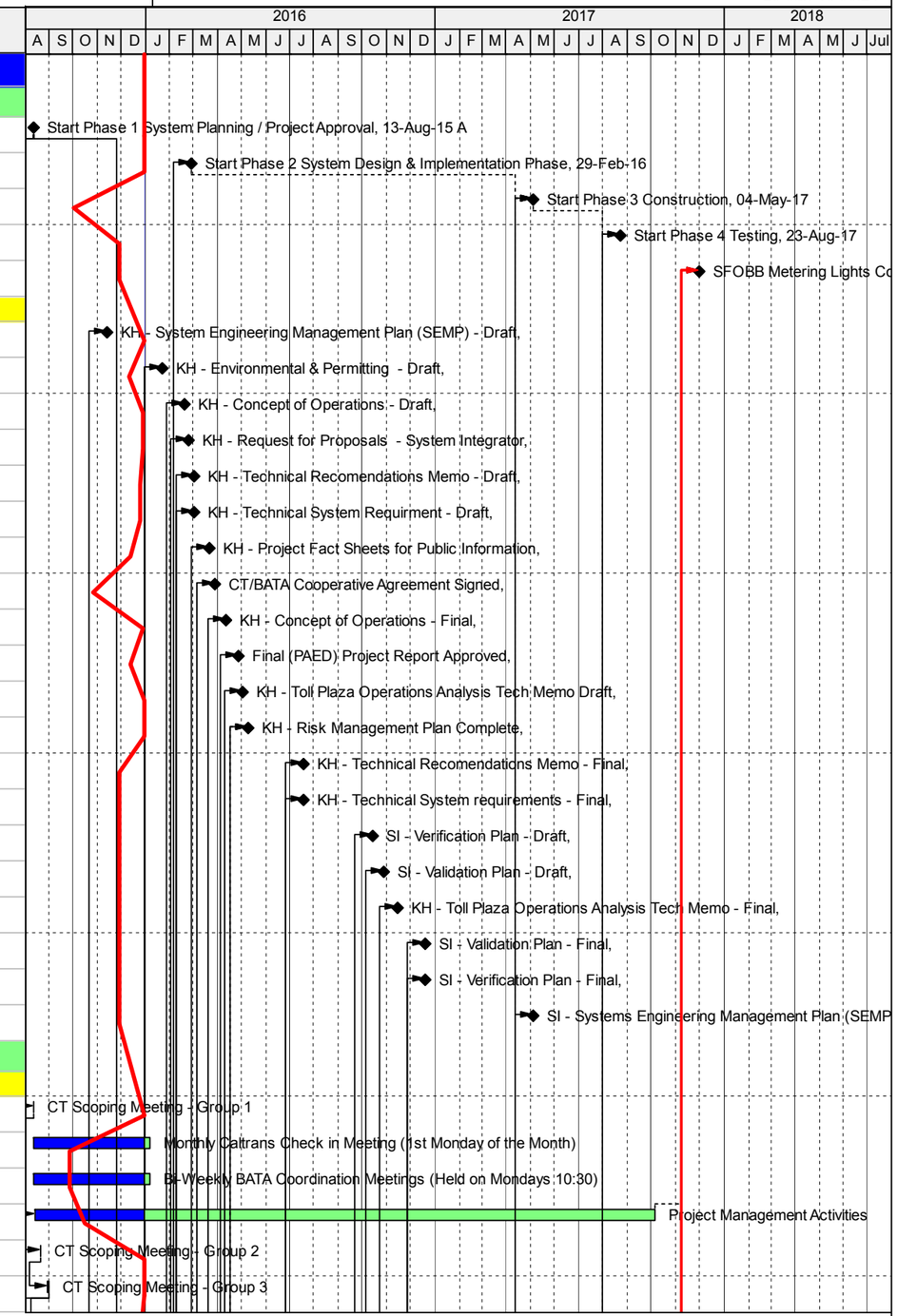
APPENDIX B – STAKEHOLDER ORGANIZATION CHART

SFOBB METERING LIGHT SYSTEM UPGRADE
STAKEHOLDER ORGANIZATION CHART



APPENDIX C – PROJECT SCHEDULE

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
1	**SF Bay Bridge Metering Lights**			570	13-Aug-15 A	30-Nov-17	-32	
2	**Milestones**			570	13-Aug-15 A	30-Nov-17	-32	
3	ML_1000	BATA	Start Phase 1 System Planning / Project Approval	0	13-Aug-15 A			
4	ML_2000	BATA	Start Phase 2 System Design & Implementation Phase	0	29-Feb-16		406	SM_1000
5	ML_3000	BATA	Start Phase 3 Construction	0	04-May-17		112	CO_1010, ML_2000, SM_1130, CM_2100
6	ML_4000	BATA	Start Phase 4 Testing	0	23-Aug-17		35	TO_1010, ML_3000
7	ML_9900	BATA	SFOBB Metering Lights Complete	0		30-Nov-17	-32	PM_1000, TO_1050
8	**Project Deliverables**			364	13-Nov-15 A	05-May-17	110	
9	ML_1010	KH	KH - System Engineering Management Plan (SEMP) - Draft	0		13-Nov-15 A		SP_4030
10	ML_1110	KH	KH - Environmental & Permitting - Draft	0		22-Jan-16	429	PA_3000
11	ML_1050	KH	KH - Concept of Operations - Draft	0		19-Feb-16	411	SP_5550
12	ML_1130	KH	KH - Request for Proposals - System Integrator	0		25-Feb-16	407	SP_9050
13	ML_1070	KH	KH - Technical Recomendations Memo - Draft	0		02-Mar-16	403	SP_6530
14	ML_1160	KH	KH - Technical System Requirment - Draft	0		02-Mar-16	403	SP_6530
15	ML_1200	KH	KH - Project Fact Sheets for Public Information	0		22-Mar-16	389	PA_3040
16	ML_2060	KH	CT/BATA Cooperative Agreement Signed	0		29-Mar-16	384	SP_2040
17	ML_1060	KH	KH - Concept of Operations - Final	0		12-Apr-16	375	SP_5620
18	ML_1120	KH	Final (PAED) Project Report Approved	0		27-Apr-16	364	PA_3020
19	ML_1090	KH	KH - Toll Plaza Operations Analysis Tech Memo Draft	0		03-May-16	360	SD_2015
20	ML_1040	KH	KH - Risk Management Plan Complete	0		09-May-16	356	RM_ 1010, RM_ 1030
21	ML_1080	KH	KH - Technical Recomendations Memo - Final	0		19-Jul-16	307	SI_1060
22	ML_1170	KH	KH - Technical System requirements - Final	0		19-Jul-16	307	SI_1060
23	ML_2020	SI	SI - Verification Plan - Draft	0		13-Oct-16	247	SI_3010
24	ML_2030	SI	SI - Validation Plan - Draft	0		27-Oct-16	237	SI_3120
25	ML_1100	KH	KH - Toll Plaza Operations Analysis Tech Memo - Final	0		15-Nov-16	225	SD_2035
26	ML_2040	SI	SI - Validation Plan - Final	0		20-Dec-16	202	SI_3150
27	ML_2050	SI	SI - Verification Plan - Final	0		20-Dec-16	202	SI_3050
28	ML_2010	SI	SI - Systems Engineering Management Plan (SEMP) -Final	0		05-May-17	110	SI_2570
29	**1.0 Phase 1 Concept of Operations**			544	13-Aug-15 A	06-Oct-17	3	
30	**1.1 Project Management**			544	13-Aug-15 A	06-Oct-17	3	
31	PM_1020	KH	CT Scoping Meeting - Group 1	1	13-Aug-15 A	13-Aug-15 A		ML_1000
32	PM_1050	KH	Monthly Caltrans Check in Meeting (1st Monday of the Month)	5	13-Aug-15 A	07-Jan-16	439	
33	PM_1060	KH	Bi-Weekly BATA Coordination Meetings (Held on Mondays 10:30)	5	13-Aug-15 A	07-Jan-16	439	
34	PM_1000	KH	Project Management Activities	450	14-Aug-15 A	06-Oct-17	3	ML_1000
35	PM_1030	CT	CT Scoping Meeting - Group 2	1	21-Aug-15 A	21-Aug-15 A		PM_1020
36	PM_1040	CT	CT Scoping Meeting - Group 3	1	31-Aug-15 A	31-Aug-15 A		PM_1030



Actual Level of Effort | Critical Remaining Work
Actual Work | ◆ Milestone
Remaining Work

Metropolitan Transportation Commission SFOBB Metering Lights
Update 01 December 31, 2015 Rev 1 30Nov17 Finish

Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
37	**1.2 System Planning/Project Approval Phase**			213	13-Aug-15 A	22-Jun-16	325	
38	**1.2.1 Develop/Update Project Schedule**			87	13-Aug-15 A	07-Jan-16	439	
39	SP_1010	KH	Initial Project Schedule	87	13-Aug-15 A	06-Jan-16	32	ML_1000
40	SP_1020	BATA	Monthly Updates on 2nd Meeting of the Month(Check Calendar)	5	13-Aug-15 A	07-Jan-16	439	
41	**1.2.2 Develop Project Scope of Work**			132	13-Aug-15 A	29-Feb-16	7	
42	SP_2000	KH	Project Scope of Work - KH (System Design,Mega ICM,) Draft	70	13-Aug-15 A	23-Nov-15 A		ML_1000
43	SP_2005	BATA	BATA Review KH Scope of Work	25	24-Nov-15 A	31-Dec-15	0	SP_2000
44	SP_2015	BATA	Prepare for BATA Board	26	04-Jan-16	09-Feb-16	0	SP_2005
45	SP_2025	BATA	BATA Board Meeting	1	10-Feb-16*	10-Feb-16	0	SP_2015
46	SP_2035	BATA	KH Contract Execution for System Design	10	11-Feb-16	26-Feb-16	7	SP_2025
47	SP_2045	BATA	KH Notice to Proceed for System Design	0	29-Feb-16		7	SP_2035
48	**1.2.3 Cooperative Agreement BATA / Caltrans**			154	13-Aug-15 A	29-Mar-16	384	
49	SP_2020	BATA	Circulate Draft Cooperative Agreement - BATA Review	114	13-Aug-15 A	29-Jan-16	32	SP_2010
50	SP_2010	BATA	BATA Receive Draft Cooperative Agreement from Caltrans	1	16-Nov-15 A	16-Nov-15 A		SP_1010
51	SP_2030	BATA	Caltrans Prepare Final Cooperative Agreement	20	01-Feb-16	01-Mar-16	32	SP_2020
52	SP_2040	BATA	Final Cooperative Agreement Issued	20	02-Mar-16	29-Mar-16	384	SP_2030
53	SP_2050	BATA	Prepare QMP/Project Management Plan	5	02-Mar-16	08-Mar-16	32	SP_2030
54	**1.2.4 Procurement Options for System/ Integrator/Construction Contracts**			70	13-Aug-15 A	23-Nov-15 A		
55	SP_3010	KH	Draft Procurement Options - System Integrator BATA	16	13-Aug-15 A	03-Sep-15 A		ML_1000
56	SP_3020	KH	Bata Review Options for System Integrator	20	04-Sep-15 A	05-Oct-15 A		SP_3010
57	SP_3030	KH	Final Draft Procurement Options - System Integrator to BATA	23	06-Oct-15 A	05-Nov-15 A		SP_3020
58	SP_3040	KH	Submit to Bata for Review (A. Framier) - System Integrator	5	06-Nov-15 A	13-Nov-15 A		SP_3030
59	SP_3050	BATA	System Integrator - Approval from BATA	1	16-Nov-15 A	16-Nov-15 A		SP_3040
60	SP_3060	BACT	Discuss System Integrator with Caltrans	5	17-Nov-15 A	23-Nov-15 A		SP_3050
61	SP_3070	KH	Finalize Procurement Options	0		23-Nov-15 A		SP_3060
62	**1.2.5 Concept of Operations/Needs Assessment**			171	01-Sep-15 A	12-Apr-16	-2	
63	SP_5510	KH	Con Ops Workshop - mini -meetings, come together	5	01-Sep-15 A	08-Sep-15 A		PM_1040
64	SP_5520	KH	KH - Prepare Draft ConOps - Outline	41	10-Sep-15 A	05-Nov-15 A		SP_5510
65	SP_5525	KH	KH - Prepare Draft ConOps Report	36	06-Nov-15 A	11-Jan-16	-32	SP_5520
66	SP_5530	BATA	BATA Internal Review Draft ConOps Report Stephen/Lynn/Peter/Derrick	15	12-Jan-16	02-Feb-16	-24	SP_5520, SP_5525
67	SP_5540	BATA	Meet to discuss Comments on BATA Internal Review	1	03-Feb-16	03-Feb-16	-24	SP_5530
68	SP_5550	KH	Prepare Revision 2 ConOps	10	04-Feb-16	19-Feb-16	-24	SP_5540
69	SP_5560	KH	Submit Revison 2 ConOps to Caltrans	0		19-Feb-16	-24	SP_5550
70	SP_5570	CT	Caltrans Review Revision 2 ConOps	15	22-Feb-16	11-Mar-16	-2	SP_5560
71	SP_5580	KH	Prepare Final ConOps	10	29-Feb-16	11-Mar-16	-2	SP_5570
72	SP_5590	KH	Submit Final ConOps Review to BATA, Caltrans	15	14-Mar-16	04-Apr-16	-2	SP_5580
73	SP_5600	BATA	Meet with BATA, Caltrans for Review ConOps	1	05-Apr-16	05-Apr-16	-2	SP_5590

Actual Level of Effort
Critical Remaining Work
Actual Work
Milestone
Remaining Work

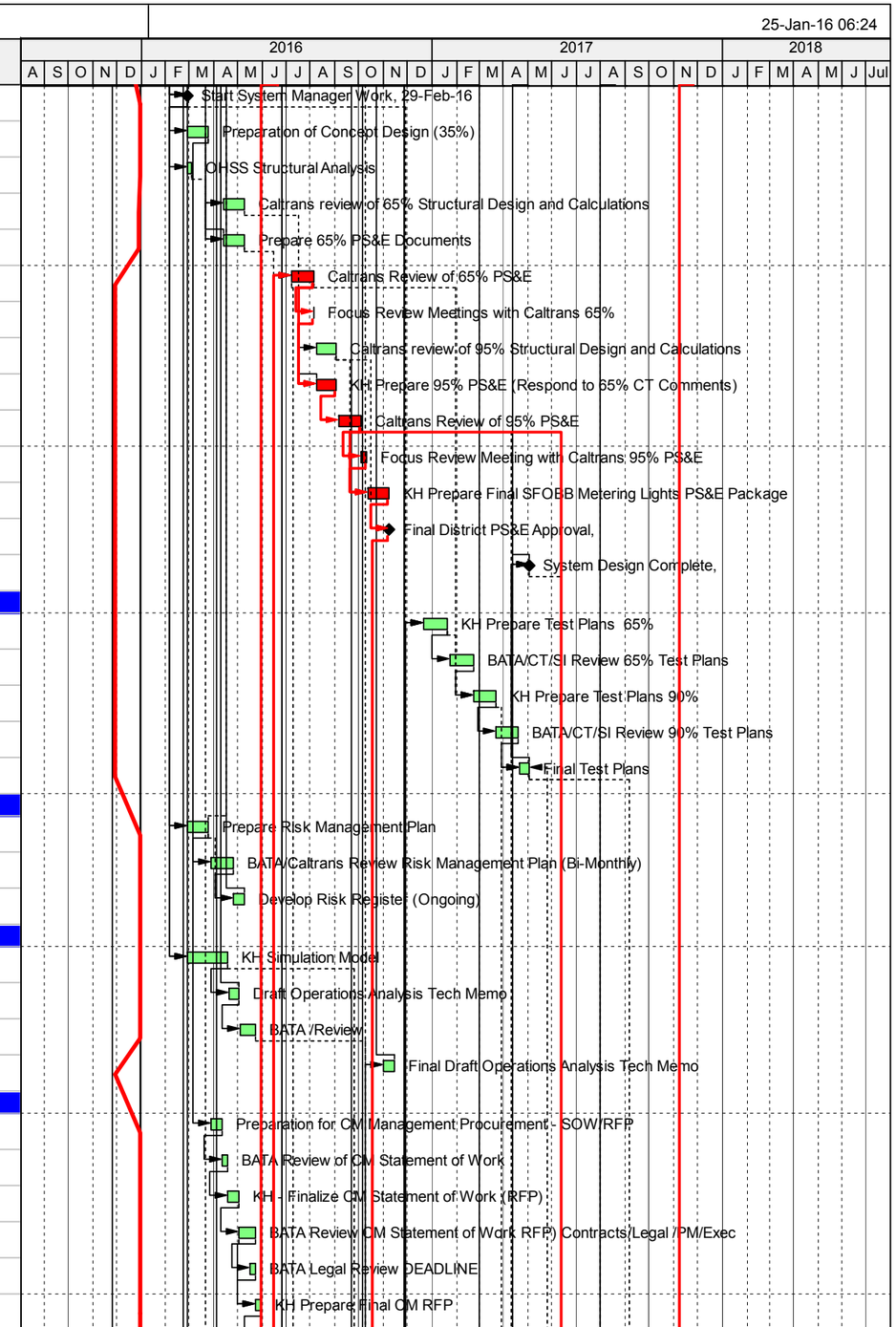
Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
74	SP_5610	BACT	Final CommentsI ConOps - BATA/Caltrans	5	06-Apr-16	12-Apr-16	-2	SP_5600
75	SP_5620	BACT	Issue - Final ConOps - BATA/Caltrans	0		12-Apr-16	-2	SP_5610
76	**1.2.6 Systems Engineering Management Plan (SEMP) Draft**			95	13-Aug-15 A	31-Dec-15	443	
77	SP_4020	KH	Receive DATA inputs from Caltrans	10	13-Aug-15 A	26-Aug-15 A		PM_1040
78	SP_4030	KH	Draft SEMP Framework	41	27-Aug-15 A	26-Oct-15 A		SP_4020
79	SP_4040	BATA	BATA Review Draft SEMP	20	27-Oct-15 A	24-Nov-15 A		SP_4030
80	SP_4050	BATA	BATA issuse to Caltrans with Con Ops for Information	1	31-Dec-15	31-Dec-15	443	SP_4040
81	**1.2.7 Metering Lights System Requirement - Draft**			44	12-Jan-16	16-Mar-16	-32	
82	SP_6510	KH	Prepare Draft Technical Systems Requirements	30	12-Jan-16	25-Feb-16	-32	SP_5525
83	SP_6545	KH	CMS Requirements	5	12-Jan-16	19-Jan-16	-3	SP_6510
84	SP_6520	KH	DRAFT CT System Requirements Workshop	4	26-Feb-16	02-Mar-16	-32	SP_6510
85	SP_6530	KH	Submit Revised Draft System Req for BATA/Caltrans Review	0		02-Mar-16	-32	SP_6520, SP_5560, SP_6545
86	SP_6540	KH	BATA/Caltrans Review DRAFT System Requirements	10	03-Mar-16	16-Mar-16	-32	SP_6530
87	SP_6550	KH	1.2.7 Draft System Requirement Complete	0		16-Mar-16	-32	SP_6540
88	**1.2.8 Develop Procurement Documents for System Integrator**			143	24-Nov-15 A	22-Jun-16	-32	
89	SP_9000	KH	KH - Prepare System Intetgrator Procurement - SOW/RFP - Draft	10	24-Nov-15 A	04-Jan-16	-18	SP_3070
90	SP_9010	BATA	BATA Review Draft SI Statement of Work/RFP - Draft	5	05-Jan-16	11-Jan-16	-18	SP_9000
91	SP_9020	KH	KH - Finalize SI Statement of Work /(RFP)	10	12-Jan-16	26-Jan-16	-18	SP_9010
92	SP_9030	BATA	BATA Internal Review SI SOW/RFP) Contracts/Legal /PM/Exec	15	27-Jan-16	18-Feb-16	-18	SP_9020
93	SP_9025	BATA	Industry Outreach (1 week review 1 week meeting with potentials)	10	29-Jan-16	11-Feb-16	-15	SP_9020
94	SP_9040	BATA	BATA Legal Review DEADLINE	5	10-Feb-16	18-Feb-16	-18	SP_9030
95	SP_9050	KH	KH Prepare Final SI Request for Proposal (RFP)	5	19-Feb-16	25-Feb-16	-18	SP_9030, SP_9040, SP_9025
96	SP_9060	BATA	RFP Advertise for System Integrator	20	17-Mar-16	14-Apr-16*	-32	SP_5550, SP_9050, SP_4040, SP_6540,
97	SP_9070	BATA	Pre-Proposal Meeting	1	24-Mar-16	24-Mar-16	-23	SP_9060
98	SP_9080	BATA	Closing Date for Requests for Information	1	01-Apr-16	01-Apr-16	-23	SP_9070
99	SP_9090	BATA	SI Integrator Closing Date for Receipt of Proposals	0		14-Apr-16	-32	SP_9060, SP_9080
100	SP_9095	BATA	BATA/KH Review RFP/SOQ Review/Ranking Selection	5	15-Apr-16	21-Apr-16	-32	SP_9090
101	SP_9100	BATA	Interviews (If Necessary)	5	22-Apr-16	28-Apr-16	-32	SP_9095
102	SP_9110	BATA	Review and Select System Integrator (BAFO)	10	29-Apr-16	12-May-16	-32	SP_9060, SP_9090, SP_9100
103	SP_9115	BATA	Prepare Agenda Item, Signatures and Review	13	13-May-16	01-Jun-16	-32	SP_9110
104	SP_9120	BATA	BATA Agenda Package Mail-out (5-Day prior to Meeting)	0		01-Jun-16*	-32	SP_9110, SP_9115
105	SP_9125	BATA	BATA Oversight Approval	1	08-Jun-16	08-Jun-16	-32	SP_9120
106	SP_9130	BATA	Execution of Contract	10	09-Jun-16	22-Jun-16	-32	SP_9120, SP_9125
107	SP_9140	BATA	BATA issues NTP for System Integrator	0		22-Jun-16	-32	SP_9130
108	**Phase 2 Design**			342	18-Dec-15 A	05-May-17	110	
109	**2.1 System Manager Oversite**			294	29-Feb-16	03-May-17	112	
110	**2.1.0 System Design General**			294	29-Feb-16	03-May-17	10	

Actual Level of Effort | Critical Remaining Work
Actual Work | ◆ Milestone
Remaining Work

Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
111	SM_1000	KH	Start System Manager Work	0	29-Feb-16		7	SP_9000, SP_3070, SP_2045
112	SM_1010	KH	Preparation of Concept Design (35%)	20	29-Feb-16	25-Mar-16	7	SM_1000
113	SM_1015	KH	OHSS Structural Analysis	5	29-Feb-16	04-Mar-16	55	SM_1000
114	SM_1020	CT	Caltrans review of 65% Structural Design and Calculations	20	13-Apr-16	10-May-16	29	SM_1030, SM_1015
115	SM_1030	KH	Prepare 65% PS&E Documents	20	13-Apr-16	10-May-16	-2	SM_1010, SP_5620
116	SM_1040	CT	Caltrans Review of 65% PS&E	20	08-Jul-16	04-Aug-16	-32	PA_2120, PA_2130, SM_1030, SI_1030
117	SM_1050	CT	Focus Review Meetings with Caltrans 65%	1	05-Aug-16	05-Aug-16	-32	SM_1040
118	SM_1060	CT	Caltrans review of 95% Structural Design and Calculations	20	08-Aug-16	02-Sep-16	-7	SM_1070
119	SM_1070	KH	KH Prepare 95% PS&E (Respond to 65% CT Comments)	20	08-Aug-16	02-Sep-16	-32	SM_1040, SM_1020, SM_1050
120	SM_1080	CT	Caltrans Review of 95% PS&E	20	06-Sep-16	03-Oct-16	-32	SM_1070
121	SM_1100	CT	Focus Review Meeting with Caltrans 95% PS&E	5	04-Oct-16	11-Oct-16	-32	SM_1080
122	SM_1110	KH	KH Prepare Final SFOBB Metering Lights PS&E Package	20	12-Oct-16	08-Nov-16	-32	SM_1080, SM_1060, SM_1100
123	SM_1120	CT	Final District PS&E Approval	0		08-Nov-16	-32	SM_1110, SM_1060
124	SM_1130	KH	System Design Complete	0		03-May-17	10	TP_1046, SI_2000, SM_1080
125	**2.1.3 Development of Test Plans**			**90**	**21-Dec-16**	**03-May-17**	**10**	
126	TP_1014	KH	KH Prepare Test Plans 65%	20	21-Dec-16	20-Jan-17	10	SM_1000, SI_3150, SI_1060
127	TP_1015	BACT	BATA/CT/SI Review 65% Test Plans	20	23-Jan-17	21-Feb-17	10	TP_1014
128	TP_1018	KH	KH Prepare Test Plans 90%	20	22-Feb-17	21-Mar-17	10	TP_1014, SM_1040, TP_1015
129	TP_1028	BACT	BATA/CT/SI Review 90% Test Plans	20	22-Mar-17	19-Apr-17	10	TP_1018
130	TP_1046	KH	Final Test Plans	10	20-Apr-17	03-May-17	10	TP_1018, SI_2500, SI_3200, TP_1028
131	**2.1.4 Risk Management Plan**			**50**	**29-Feb-16**	**09-May-16**	**356**	
132	RM_ 1010	KH	Prepare Risk Management Plan	20	29-Feb-16	25-Mar-16	356	SP_4040, SP_2045
133	RM_ 1020	BACT	BATA/Caltrans Review Risk Management Plan (Bi-Monthly)	20	28-Mar-16	25-Apr-16	356	RM_ 1010
134	RM_ 1030	KH	Develop Risk Register (Ongoing)	10	26-Apr-16	09-May-16	356	RM_ 1010, RM_ 1020
135	**2.1.5 Simulation / Traffic & Toll Plaza Operations Analysis**			**181**	**29-Feb-16**	**15-Nov-16**	**225**	
136	SD_2000	KH	KH Simulation Model	36	29-Feb-16	19-Apr-16	178	SP_2000, SM_1000
137	SD_2015	KH	Draft Operations Analysis Tech Memo	10	20-Apr-16	03-May-16	335	SD_2000
138	SD_2025	BATA	BATA /Review	15	04-May-16	24-May-16	335	SD_2015
139	SD_2035	KH	Final Draft Operations Analysis Tech Memo	10	01-Nov-16	15-Nov-16	225	SD_2025, SI_2530
140	**2.1.7 Construction Management Service Procurement**			**88**	**28-Mar-16**	**01-Aug-16**	**7**	
141	CM_1000	KH	Preparation for CM Management Procurement - SOW/RFP	10	28-Mar-16	11-Apr-16	7	SM_1010
142	CM_1010	BATA	BATA Review of CM Statement of Work	5	12-Apr-16	18-Apr-16	7	CM_1000
143	CM_1020	KH	KH - Finalize CM Statement of Work (RFP)	10	19-Apr-16	02-May-16	7	CM_1010
144	CM_1030	BATA	BATA Review CM Statement of Work RFP) Contracts/Legal /PM/Exec	15	03-May-16	23-May-16	7	CM_1020
145	CM_1041	BATA	BATA Legal Review DEADLINE	5	17-May-16	23-May-16	7	CM_1030
146	CM_1051	KH	KH Prepare Final CM RFP	5	24-May-16	31-May-16	7	CM_1030, CM_1041

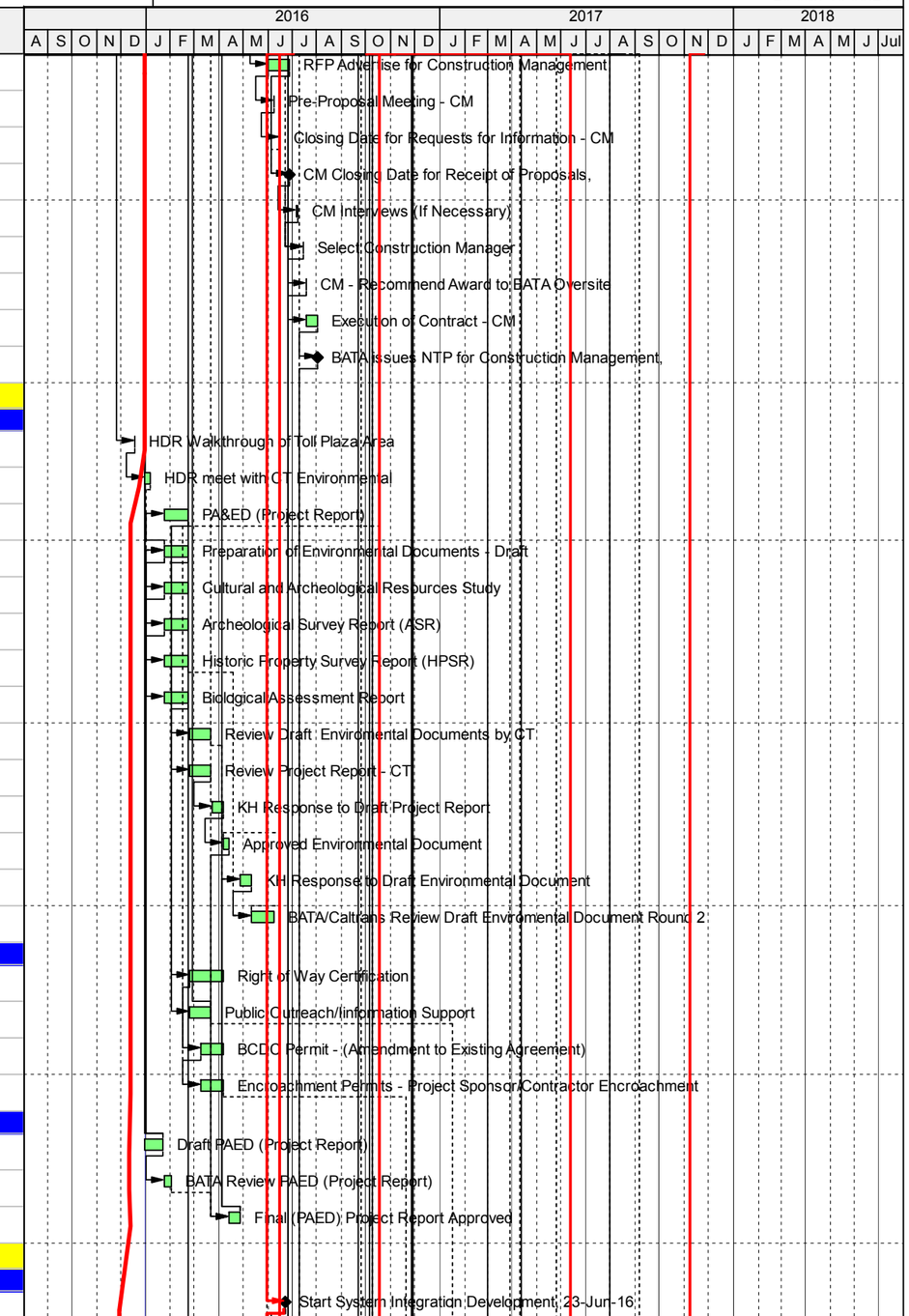


Actual Level of Effort
Critical Remaining Work
Actual Work
◆ Milestone
Remaining Work

Metropolitan Transportation Commission SFOBB Metering Lights
Update 01 December 31, 2015 Rev 1 30Nov17 Finish

Date	Revision	Checked	Approved

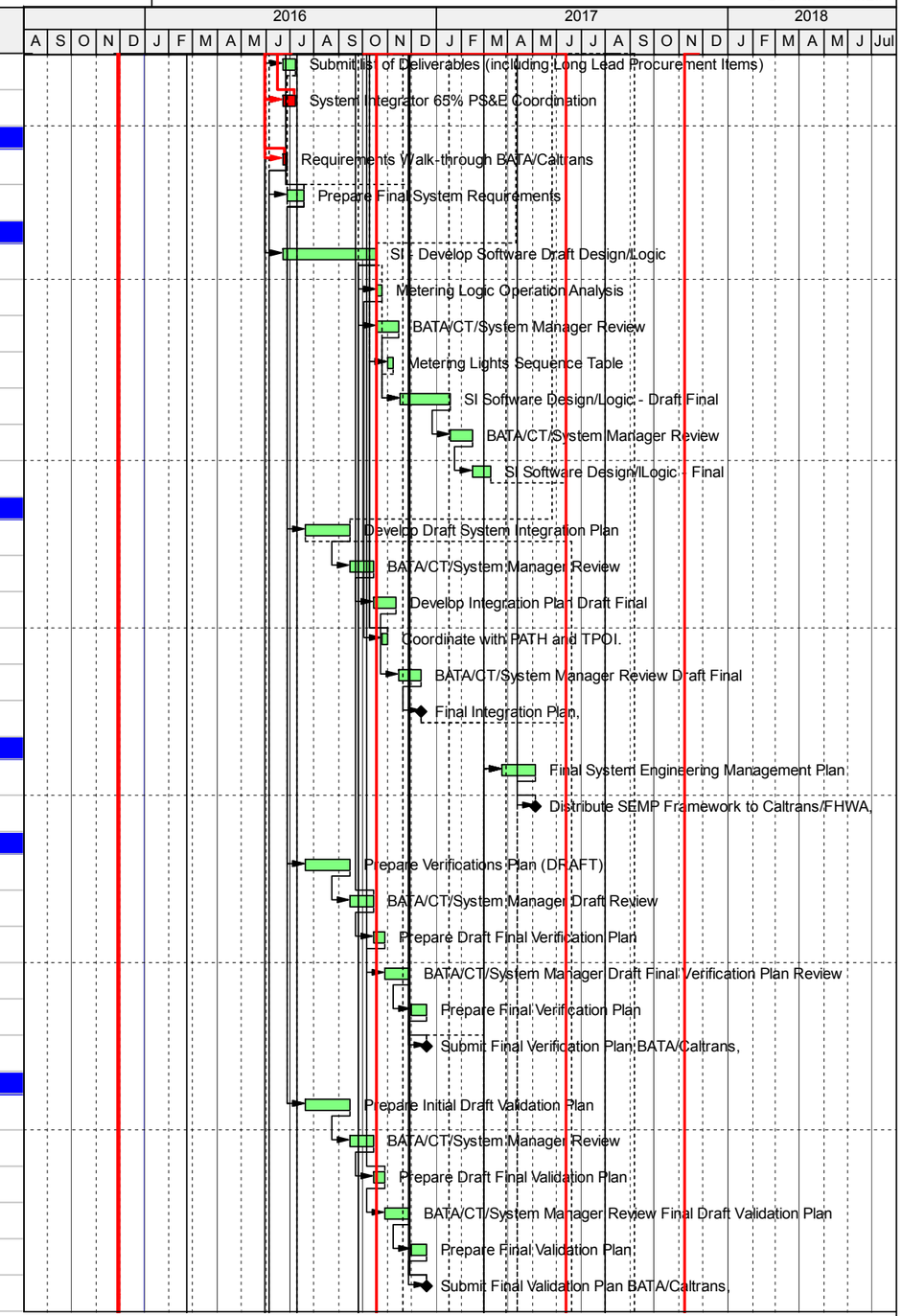
#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
147	CM_1060	BATA	RFP Advertise for Construction Management	20	01-Jun-16	28-Jun-16	7	CM_1051
148	CM_1070	BATA	Pre-Proposal Meeting - CM	1	08-Jun-16	08-Jun-16	16	CM_1060
149	CM_1080	BATA	Closing Date for Requests for Information - CM	1	15-Jun-16	15-Jun-16	16	CM_1070
150	CM_1091	BATA	CM Closing Date for Receipt of Proposals	0		28-Jun-16	7	CM_1060, CM_1080
151	CM_1100	BATA	CM Interviews (If Necessary)	1	07-Jul-16	07-Jul-16	7	CM_1091
152	CM_1110	BATA	Select Construction Manager	1	15-Jul-16	15-Jul-16	7	CM_1060, CM_1091, CM_1100
153	CM_1120	BATA	CM - Recommend Award to BATA Oversite	1	18-Jul-16	18-Jul-16	7	CM_1110
154	CM_1130	BATA	Execution of Contract - CM	10	19-Jul-16	01-Aug-16	7	CM_1120
155	CM_1140	BATA	BATA issues NTP for Construction Management	0		01-Aug-16	7	CM_1130
156	**2.2 Civil**			118	18-Dec-15 A	09-Jun-16	132	
157	**2.2.1 Project Approval & Environmental Documentation (PAED)**			118	18-Dec-15 A	09-Jun-16	7	
158	PA_2000	HDR	HDR Walkthrough of Toll Plaza Area	1	18-Dec-15 A	18-Dec-15 A		ML_1000
159	PA_2010	HDR	HDR meet with CT Environmental	5	31-Dec-15	07-Jan-16	17	PA_2000
160	PA_2020	HDR	PA&ED (Project Report)	20	25-Jan-16	23-Feb-16	7	PA_2030
161	PA_2030	HDR	Preparation of Environmental Documents - Draft	20	25-Jan-16	23-Feb-16	7	PA_3000, PA_2010
162	PA_2040	HDR	Cultural and Archeological Resources Study	20	25-Jan-16	23-Feb-16	62	PA_2030
163	PA_2050	HDR	Archeological Survey Report (ASR)	20	25-Jan-16	23-Feb-16	62	PA_2040
164	PA_2060	HDR	Historic Property Survey Report (HPSR)	20	25-Jan-16	23-Feb-16	62	PA_2050
165	PA_2070	HDR	Biological Assessment Report	20	25-Jan-16	23-Feb-16	32	PA_2030
166	PA_2080	HDR	Review Draft Enviromental Documents by CT	20	24-Feb-16	22-Mar-16	32	PA_2030, PA_2070
167	PA_2090	CT	Review Project Report - CT	20	24-Feb-16	22-Mar-16	7	PA_2020
168	PA_2110	HDR	KH Response to Draft Project Report	10	23-Mar-16	06-Apr-16	7	PA_2090
169	PA_2130	BACT	Approved Environmental Document	5	07-Apr-16	13-Apr-16	7	PA_2110
170	PA_2100	HDR	KH Response to Draft Environmental Document	10	28-Apr-16	11-May-16	7	PA_3020, PA_2080
171	PA_2120	BACT	BATA/Caltrans Review Draft Enviromental Document Round 2	20	12-May-16	09-Jun-16	7	PA_2100, PA_2060
172	**2.2.2 Environmental**			30	24-Feb-16	06-Apr-16	177	
173	PA_3030	CT	Right of Way Certification	30	24-Feb-16	06-Apr-16	138	PA_2020
174	PA_3040	CT	Public Outreach/Iinformation Support	20	24-Feb-16	22-Mar-16	187	PA_2020
175	PA_3050	BCDC	BCDC Permit - (Amendment to Existing Agreement)	20	09-Mar-16	06-Apr-16	138	PA_2020, PA_3030
176	PA_3060	CT	Encroachment Permits - Project Sponsor/Contractor Encroachment	20	09-Mar-16	06-Apr-16	138	PA_3050, PA_3030
177	**2.2.3 Caltrans / BATA Permits**			80	31-Dec-15	27-Apr-16	7	
178	PA_3000	CT	Draft PAED (Project Report)	15	31-Dec-15	22-Jan-16	7	
179	PA_3010	BATA	BATA Review PAED (Project Report)	7	25-Jan-16	02-Feb-16	55	PA_3000
180	PA_3020	CT	Final (PAED) Project Report Approved	10	14-Apr-16	27-Apr-16	7	PA_3010, PA_2130, SP_2050
181	**2.3 System Integration**			215	23-Jun-16	05-May-17	110	
182	**2.3.0 System Integration General**			10	23-Jun-16	07-Jul-16	18	
183	SI_1000	SI	Start System Integration Development	0	23-Jun-16		-32	SP_9140



Actual Level of Effort
Critical Remaining Work
Actual Work
Milestone
Remaining Work

Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
184	SI_1020	SI	Submit list of Deliverables (including Long Lead Procurement Items)	10	23-Jun-16	07-Jul-16	18	SI_1000
185	SI_1030	SI	System Integrator 65% PS&E Coordination	10	23-Jun-16	07-Jul-16	-32	SI_1000, SM_1030, SI_1050
186	**2.3.1 Metering System Requirements (Final)**			18	23-Jun-16	19-Jul-16	10	
187	SI_1050	SI	Requirements Walk-through BATA/Caltrans	3	23-Jun-16	27-Jun-16	-32	SI_1000
188	SI_1060	SI	Prepare Final System Requirements	15	28-Jun-16	19-Jul-16	10	SI_1050
189	**2.3.2 Software Design / Logic**			175	23-Jun-16	09-Mar-17	48	
190	SI_2000	SI	SI - Develop Software Draft Design/Logic	80	23-Jun-16	17-Oct-16	48	SI_1000
191	SI_2010	SI	Metering Logic Operation Analysis	5	18-Oct-16	24-Oct-16	53	SD_2000, SI_2000
192	SI_2020	BACT	BATA/CT/System Manager Review	20	18-Oct-16	15-Nov-16	48	SI_2000
193	SI_2030	SI	Metering Lights Sequence Table	5	01-Nov-16	07-Nov-16	53	SP_5540, SI_2530, SI_2000
194	SI_2040	SI	SI Software Design/Logic - Draft Final	40	16-Nov-16	17-Jan-17	48	SI_2000, SI_2020, SI_2030
195	SI_2050	BACT	BATA/CT/System Manager Review	20	18-Jan-17	15-Feb-17	48	SI_2040
196	SI_2060	SI	SI Software Design/lLogic - Final	15	16-Feb-17	09-Mar-17	48	SI_2050
197	**2.3.3 Integration Plan (ATMS and CMS)**			100	20-Jul-16	13-Dec-16	105	
198	SI_2500	SI	Develop Draft System Integration Plan	40	20-Jul-16	14-Sep-16	105	SI_1060
199	SI_2510	SI	BATA/CT/System Manager Review	20	15-Sep-16	13-Oct-16	105	SI_2500
200	SI_2520	SI	Develop Integration Plan Draft Final	20	14-Oct-16	10-Nov-16	105	SI_2510
201	SI_2530	SI	Coordinate with PATH and TPOI.	5	25-Oct-16	31-Oct-16	53	SI_2010
202	SI_2540	BACT	BATA/CT/System Manager Review Draft Final	20	14-Nov-16	13-Dec-16	105	SI_2520
203	SI_2550	SI	Final Integration Plan	0		13-Dec-16	105	SI_2540
204	**2.3.4 Systems Engineering Management Plan - Final**			30	24-Mar-17	05-May-17	110	
205	SI_2560	SI	Final System Engineering Management Plan	30	24-Mar-17	05-May-17	110	SP_4040, SI_2550, SI_3200, SI_3050,
206	SI_2570	SI	Distribute SEMP Framework to Caltrans/FHWA	0		05-May-17	110	SI_2560
207	**2.3.5 Verification Plan**			105	20-Jul-16	20-Dec-16	172	
208	SI_3000	SI	Prepare Verifications Plan (DRAFT)	40	20-Jul-16	14-Sep-16	172	SI_1020, SI_1060
209	SI_3010	BACT	BATA/CT/System Manager Draft Review	20	15-Sep-16	13-Oct-16	172	SI_3000
210	SI_3020	SI	Prepare Draft Final Verification Plan	10	14-Oct-16	27-Oct-16	172	SI_3010
211	SI_3030	BACT	BATA/CT/System Manager Draft Final Verification Plan Review	20	28-Oct-16	29-Nov-16	172	SI_3020
212	SI_3040	SI	Prepare Final Verification Plan	15	30-Nov-16	20-Dec-16	172	SI_3030
213	SI_3050	SI	Submit Final Verification Plan BATA/Caltrans	0		20-Dec-16	172	SI_3040
214	**2.3.6 Validation Plan**			105	20-Jul-16	20-Dec-16	10	
215	SI_3100	SI	Prepare Initial Draft Validation Plan	40	20-Jul-16	14-Sep-16	10	SI_1020, SI_1060
216	SI_3110	BACT	BATA/CT/System Manager Review	20	15-Sep-16	13-Oct-16	10	SI_3100
217	SI_3120	SI	Prepare Draft Final Validation Plan	10	14-Oct-16	27-Oct-16	10	SI_3110
218	SI_3130	BACT	BATA/CT/System Manager Review Final Draft Validation Plan	20	28-Oct-16	29-Nov-16	10	SI_3120
219	SI_3140	SI	Prepare Final Validation Plan	15	30-Nov-16	20-Dec-16	10	SI_3130
220	SI_3150	SI	Submit Final Validation Plan BATA/Caltrans	0		20-Dec-16	10	SI_3140



Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
Milestone

Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
221	**2.3.7 Operation & Maintenance Plans**			61	18-Oct-16	18-Jan-17	154	
222	SI_3200	SI	SI - Operations and Maintenance Plan Draft	21	18-Oct-16	16-Nov-16	112	SI_2000
223	SI_3210	BACT	BATA/CT/System Manger Review O&M Draft	20	17-Nov-16	16-Dec-16	154	SI_3200
224	SI_3220	SI	Prepare Final Operation & Management Plan	20	19-Dec-16	18-Jan-17	154	SI_3210
225	SI_3230	SI	Submit Final Operations & Management Plan	0		18-Jan-17	154	SI_3220
226	**2.3.8 Configuration Management Plan**			80	28-Jun-16	20-Oct-16	212	
227	SI_3300	SI	Develop Configuration Management Plan - Draft	20	28-Jun-16	26-Jul-16	212	SI_1000, SI_1050
228	SI_3310	SI	BATA/Caltrans/System Manager Review Config Management Draft	20	27-Jul-16	23-Aug-16	212	SI_3300
229	SI_3320	SI	Configuration Management Plan - Final	20	24-Aug-16	21-Sep-16	212	SI_3310
230	SI_3330	SI	BATA/CAltrans/System Manager Review - Final	20	22-Sep-16	20-Oct-16	212	SI_3320
231	**2.3.9 Training Plan**			80	23-Jun-16	17-Oct-16	215	
232	SI_3400	SI	Develop Draft Training Plan	20	23-Jun-16	21-Jul-16	215	SI_1000
233	SI_3410	BACT	BATA/Caltrans/System Manage Review Draft Training Plan	20	22-Jul-16	18-Aug-16	215	SI_3400
234	SI_3420	SI	Develop Final Training Plan	20	19-Aug-16	16-Sep-16	215	SI_3410
235	SI_3430	BACT	BATA/Caltrans/System Manager Review Final Training Plan	20	19-Sep-16	17-Oct-16	215	SI_3420
236	**2.3.10 Performance Monitoring Plan**			105	18-Oct-16	23-Mar-17	110	
237	PM_4000	SI	Prepare Performance Monitoring Plan (DRAFT)	40	18-Oct-16	15-Dec-16	110	SI_2000
238	PM_4010	BACT	BATA/CT/System Manager Review Draft Perr Monitoring Draft Review	20	16-Dec-16	17-Jan-17	110	PM_4000
239	PM_4020	SI	Prepare Draft Final Performance Monitoring Plan	10	18-Jan-17	31-Jan-17	110	PM_4010
240	PM_4030	BACT	BATA/CT/System Manager Draft Final Monitoring Plan Review	20	01-Feb-17	02-Mar-17	110	PM_4020
241	PM_4040	SI	Prepare Final Performance Monitoring Plan	15	03-Mar-17	23-Mar-17	110	PM_4030
242	PM_4050	SI	Submit Final Verification Plan BATA/Caltrans	0		23-Mar-17	110	PM_4040
243	**2.4 Procurement**			214	13-Aug-15 A	07-Nov-16	158	
244	PR_1000	BATA	Send Draft Fastrak Specificaitons to KH	20	13-Aug-15 A	11-Sep-15 A		ML_1000
245	PR_1010	KH	Request AS-Built Drawings from Caltrans	5	17-Mar-16	23-Mar-16	158	PR_1000, SP_6540
246	PR_1020	KH	Develop Metering Lights CMS Specifications	10	24-Mar-16	07-Apr-16	158	PR_1010
247	PR_1030	CT	CT Review Metering Lights CMS Specification	20	08-Apr-16	05-May-16	158	PR_1020
248	PR_1040	BATA	Issue Request for Procurement (RFP) Metering Lights CMS	25	06-May-16	10-Jun-16	158	PR_1030, PR_1030
249	PR_10501000	BATA	CMS Closing Date for Receipt of Proposals	0		10-Jun-16	158	PR_1040
250	PR_10501010	BATA	CMS Interviews (If Necessary)	1	20-Jun-16	20-Jun-16	158	PR_10501000
251	PR_10501020	BATA	Select CMS Fabricator	1	28-Jun-16	28-Jun-16	158	PR_10501000, PR_10501010
252	PR_10501030	BATA	CMS - Recommend Award to BATA Oversite	1	29-Jun-16	29-Jun-16	158	PR_10501020
253	PR_10501040	BATA	Execution of CMS Contract	10	30-Jun-16	14-Jul-16	158	PR_10501030
254	PR_10501050	BATA	BATA issues NTP for CMS Signs	0		14-Jul-16	158	PR_10501040
255	PR_10501060		Fabricate and Deliver CMS Signs	80	15-Jul-16	07-Nov-16	158	PR_10501050
256	**2.5 Construction Management**			128	02-Aug-16	07-Feb-17	-32	
257	**2.5.1 Constructability Review**			30	02-Aug-16	13-Sep-16	7	

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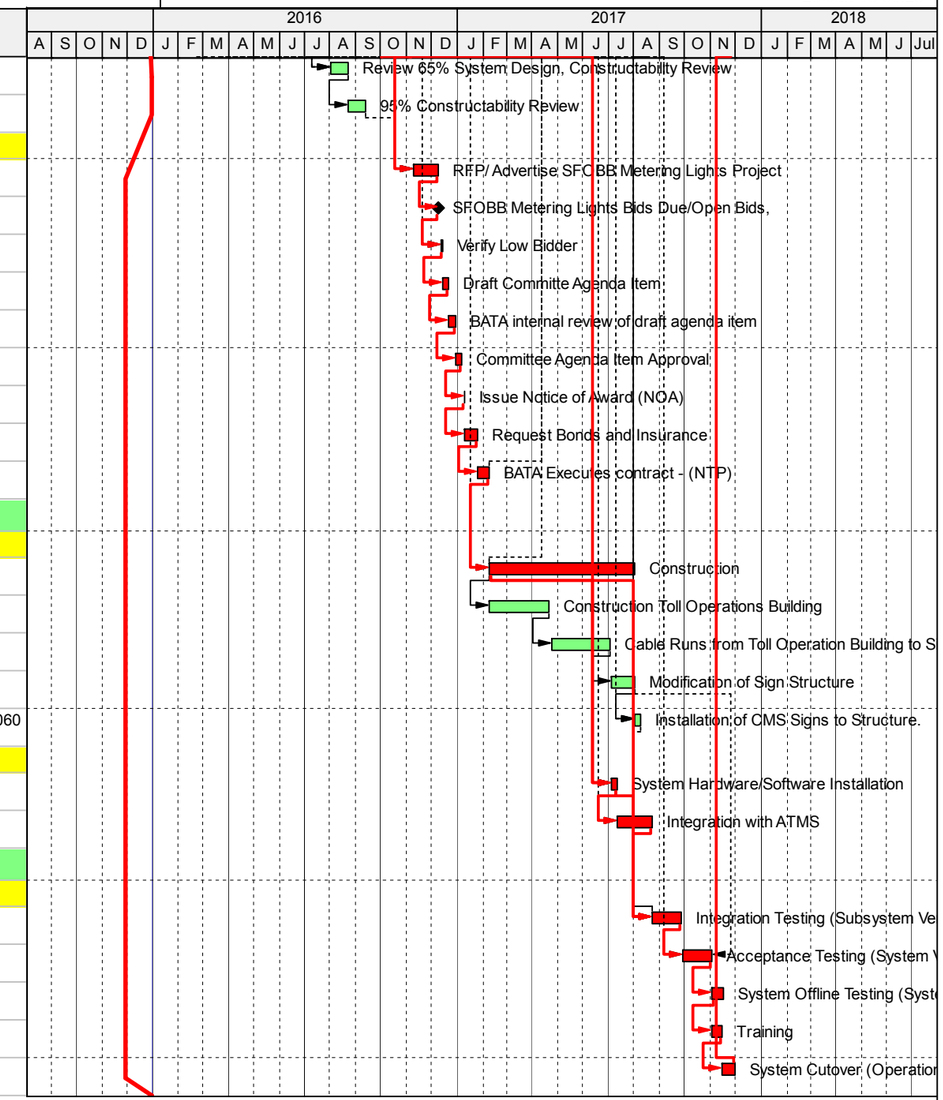
Date	Revision	Checked	Approved

#	Activity ID	Resp	Activity Name	OD	Start	Finish	TF	Predecessors
258	CM_2000	CM	Review 65% System Design, Constructability Review	15	02-Aug-16	22-Aug-16	7	SM_1040, CM_1140
259	CM_2010	CM	95% Constructability Review	15	23-Aug-16	13-Sep-16	7	CM_2000
260	**2.5.2 Develop Construction Documents**			59	09-Nov-16	07-Feb-17	-32	
261	CM_2020	BATA	RFP/ Advertise SFOBB Metering Lights Project	20	09-Nov-16	09-Dec-16	-32	PA_2020, CM_2010, SM_1120
262	CM_2030	BATA	SFOBB Metering Lights Bids Due/Open Bids	0		09-Dec-16	-32	CM_2020
263	CM_2040	BATA	Verify Low Bidder	3	12-Dec-16	14-Dec-16	-32	CM_2030, PA_3060
264	CM_2050	BATA	Draft Committe Agenda Item	5	15-Dec-16	21-Dec-16	-32	CM_2040
265	CM_2060	BATA	BATA internal review of draft agenda item	5	22-Dec-16	29-Dec-16	-32	CM_2050
266	CM_2070	BATA	Committee Agenda Item Approval	5	30-Dec-16	06-Jan-17	-32	CM_2060
267	CM_2080	BATA	Issue Notice of Award (NOA)	1	09-Jan-17	09-Jan-17	-32	CM_2070
268	CM_2090	BATA	Request Bonds and Insurance	10	10-Jan-17	24-Jan-17	-32	CM_2080
269	CM_2100	BATA	BATA Executes contract - (NTP)	10	25-Jan-17	07-Feb-17	-32	CM_2090
270	**Phase 3 Construction**			135	08-Feb-17	22-Aug-17	-32	
271	**Construction - Physical**			125	08-Feb-17	08-Aug-17	-22	
272	CO_1010	CON	Construction	120	08-Feb-17	01-Aug-17	-32	PA_3040, CM_2100
273	CO_1020	CON	Construction Toll Operations Building	50	08-Feb-17	21-Apr-17	-22	CO_1010
274	CO_1030	CON	Cable Runs from Toll Operation Building to Sign Structure	50	24-Apr-17	03-Jul-17	-22	CO_1020
275	CO_1040	CON	Modification of Sign Structure	20	05-Jul-17	01-Aug-17	-22	CO_1030
276	CO_1050	CON	Installation of CMS Signs to Structure.	5	02-Aug-17	08-Aug-17	-22	CO_1040, PR_10501060
277	**Construction - Hardware and Software**			35	05-Jul-17	22-Aug-17	-32	
278	SI_9010	SI	System Hardware/Software Installation	5	05-Jul-17	11-Jul-17	-32	CO_1010, SI_2060, SI_2550, SM_1130,
279	SI_9020	SI	Integration with ATMS	30	12-Jul-17	22-Aug-17	-32	SI_2500, SI_9010
280	**Phase 4 Testing and Operational**			67	23-Aug-17	30-Nov-17	-32	
281	**System Verificaton and Validation**			67	23-Aug-17	30-Nov-17	-32	
282	TO_1010	SI	Integration Testing (Subsystem Verifications)	25	23-Aug-17	27-Sep-17	-32	CO_1010, CO_1050, SI_9010, TP_1046,
283	TO_1020	SI	Acceptance Testing (System Verification)	25	28-Sep-17	02-Nov-17	-32	TO_1010, CO_1040, TP_1046
284	TO_1030	SI	System Offline Testing (System Validation)	10	03-Nov-17	17-Nov-17	-32	TO_1020
285	TO_1040	SI	Training	7	03-Nov-17	14-Nov-17	-32	TO_1030
286	TO_1050	SI	System Cutover (Operational)	10	15-Nov-17	30-Nov-17	-32	TO_1040



Actual Level of Effort
Actual Work
Remaining Work
Critical Remaining Work
◆ Milestone

Date	Revision	Checked	Approved

APPENDIX D – PROCUREMENT STRATEGY MEMO

Kimley»Horn

MEMORANDUM

To: Stephen Baker, Bay Area Toll Authority

From: Kevin Aguigui, P.E., CSEP, Kimley-Horn

Date: September 3, 2015
Rev. September 14, 2015
Final- November 5, 2015

Subject: SFOBB Metering Lights Upgrade – Project Delivery Options

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The Bay Area Toll Authority (BATA) is embarking on a project to upgrade the metering lights for the San Francisco-Oakland Bay Bridge (SFOBB). The upgraded metering lights system will consist of hardware and software improvements for the metering system, as well as possible communications infrastructure and field devices to support the system. The project will be managed and administered BATA through construction and systems acceptance, at which point it will be handed over to Caltrans for operations and maintenance.

The existing metering system has been operating since 1974 and is currently operated manually. An upgraded metering system will be more responsive to changing traffic conditions to improve congestion through the corridor, and require minimal manual interference.

Because of the accelerated schedule for project delivery and the complexity of the project, BATA is reviewing contracting options that will expedite the implementation of the upgraded without sacrificing quality or necessary expertise.

Description of Project Delivery Options

The following describes the possible contracting options that are available for the project.

- Design-Bid-Build - most traditional procurement option that consists of three basic stages: design, procurement, and construction. The designer completes the design to completion after which a construction contractor is selected based on a low bid.
- Design-Build – this is a method of project delivery in which one entity – the design-build team – works under a single contract to provide design and construction services. The construction contractor hires the designer who performs the final design and the contractor performs the construction and implementation of the project. The construction contractor typically provides a bid based on a partial design usually at the 10% to 30% stages. The designer and contractor also typically completes the right-of-way certification, acquires permits and environmentally clears the project.
- Design Sequencing – a method of contracting that enables construction phases to start when the design for that phase is complete instead completing the design for the entire project before beginning any construction. The award of a project to a contractor is

based on designs that are at least 30 percent complete. One of the goals of design-sequencing is to promote collaboration with the construction contractor during the remaining design process.

- Systems Manager/Systems Integrator - Systems Integrator completes design of system and either hires a contractor for the field construction, or a contractor is selected under a separate contract.
- Construction Manager/General Contractor (CMGC) – A contractor and construction manager is hired during the design phase to provide input into the design. The contractor is selected based on a Guaranteed Maximum Price (GMP), and if the GMP is agreed on, the CMGC will take the project through construction and implementation.
- Hybrid Approach - Design Sequence for civil construction and System Integrator for Software/ Hardware of metering system. This option splitting the contracts into two parts: Design Sequencing the Civil portion and hiring an Integrator for the Software/Hardware
- Incentive Based Contracting - Provide incentives for performing faster than the given schedule; Combine with other contracting mechanisms. (A+B)

The SFOBB Meeting Lights Upgrade project consists of two main elements: the first consists of field devices and the other hardware and software that receive information from, and control the field devices. Because of the nature of this type of project, the two elements require different expertise to implement. The hardware and software installation as well as the integration of the field elements with the hardware and software is performed by a System Integrator, while the installation of the field elements performed by a construction contractor. Pending final scoping of the project, it is assumed the project is primarily a software/systems project with a smaller civil component.

Table 1 below provides a summary of the pros and cons of the different project delivery types as they relate to the SFOBB Metering Lights Upgrade project.

Table 1 – Comparison of Project Delivery Methods				
Contract Type	**Pros**	**Cons**	**Schedule impacts**	**Other Considerations**
Design-Bid-Build	• There is competition from multiple bidders which tends to result in more competitive bids. • The designers have sufficient time to prepare the final design and project specifications • Most commonly used contract type • There is a price certainty since the design is developed to completion	• Competitive low bid procurements are risky for hardware and software projects since it may introduce less than qualified system integrators • The low bid process may lead to protests by potential bidders. • The contractors have a tendency seek contract change orders once under construction. • No construction contractor or system integrator input during the design, which may result in higher than expected costs.	• Protests can delay award of project • Advertising period is sequential	• Right of way, environmental documents and permits must be completed before the bid is released (advertised) • The SFOBB project may be too small for a civil contractor to bid on which could result in higher bid prices. • The prime (civil) may see the subcontractor's work as too risky (the subcontractor being a system integrator).
Design-Build	• Potential to award a contract using Best Value and not low bid. • Cost and construction and implementation schedule are known at time of contractor selection • The cost risk is transferred to the contractor • Allows contractor to be innovative in design and construction methods	• Construction contractors may not be interested in this project because the systems work is larger dollar amount than the civil work, with more inherent risk. • Little control over final design • The environmental process must be finished first • Contractor places risk into the construction cost.	• Right-of-way and utilities not resolved will cause claims and delay the project.	• Caltrans requires complete plans to secure encroachment permits • Caltrans work windows may restrict the contractor's ability to complete the project using innovative techniques.

Table 1 – Comparison of Project Delivery Methods				
Contract Type	**Pros**	**Cons**	**Schedule impacts**	**Other Considerations**
Design Sequencing	• May result in shorter schedule since design and construction carried out concurrently • Design can complete critical path work packages for contractor to start early construction resulting in shorter schedules. • Allows for blended teams with designers and the contractor working more collaboratively. • Key elements (e.g., cabinets and conduits) can be installed quickly after the construction contractor is selected.	• Little experience with design sequencing in California • May have to use low bid to select the contractor • Contractor bids on quantities at an early design stage, and as the design progresses, change orders may occur to adjust quantities based on design changes. • Contractor has no incentive for constructability reviews since the quantity bid prices are already agreed on. • Requires designers who are experienced with construction methods	• As the design progresses the contractor can get impacted by changes in the plans requiring more quantities and potential change in character claims slowing down construction. • Environmental document must be completed before construction starts. • Project changes or adjustments during construction will cause cost increases and schedule delays	• Caltrans approvals • Environmental process • Not an approved Caltrans contracting technique
System Manager/ Systems Integrator	• Can award a contract to the integrator based on a best value instead of low bid • A system integrator would be the lead for more specific technical expertise • Design of the hardware and software elements first will provide scope certainty and provide a higher quality system	• No cost or schedule savings since the Systems Integrator will still need to prepare the system design to completion before moving into construction	• Requires two advertisements, one for system integrator and one for the civil construction contractor.	

Table 1 – Comparison of Project Delivery Methods				
Contract Type	**Pros**	**Cons**	**Schedule impacts**	**Other Considerations**
Construction Manager/ General Contractor (CMGC)	• Contractor is picked on qualifications not low bid • Contractor provides input to the design to make the job more cost effective to build • Contractor identifies risks and works with client to minimize, lower claims • A guaranteed maximum Price (GMP) is agreed to before the contractor starts work • An independent cost estimate is used to help negotiate the GMP • The designers can work with the contractor to help stage the construction to allow the contractor efficiencies of staging, traffic control, earthwork balancing, etc. • One contractor is responsible for the GMP and that contractor manages the sub-contractors	• Contractor charges an up-front fee for time spent working with client • Hard to quantify savings from contractor recommendations on efficiencies • If GMP is not agreed upon the client will go out to low bid process and CMGC will be excluded from the bid. • Contractor can still price risk into the bid up front.	• Contractor doesn't have to wait for 100% plans to start construction. • Don't have to go through normal advertising period • Qualifications based selection avoids protests • Any delays due to permits and/or right of way certification will cause the contractor delays. • Delays could prompt the contractor to deploy resources to another project resulting in longer re-mobilization costs and an increase in schedule	• CMCG is a new construction tool that is having issues on several large projects where the contractor and client are far apart in with the price. • Potential duplication with AAA, CM for client, and CM with CMGC • Requires Caltrans permits. The permit process requires complete plans before a permit is issued. • If Client and contractor can't agree on a GMP then the project will become a DBB and end up taking more time to build.

Table 1 – Comparison of Project Delivery Methods				
Contract Type	**Pros**	**Cons**	**Schedule impacts**	**Other Considerations**
Combined Approach (Hybrid): Design Sequence/CM GC for civil construction and System Integrator for Software and Hardware	• Minimizes risk by allowing the selection of individual firms that are experts in their own area • Design can complete critical path work packages for contractor to start early construction.	• More contracts to manage • Little experience in CA • Contractor bids on quantities, as design progresses CCO occur to adjust quantities based on change in character.	• Potential time savings because of sequencing of construction	• Environmental process • Biggest risk is impact to schedule because of two contracts to award and coordinating the design between the two entities
Incentive Based Contracting	• May result in shorter construction schedule	• May result in higher cost • Design is 100% complete before contractor bids • Contractor will claim more time is needed for every outside impact but still want to be paid an incentive for completing the work early by subtracting out the delays		• Caltrans requirements could cause outside delays and claims by the contractor.

Conclusions

In reviewing the various project delivery method options, the goal was to determine the process that would provide the highest quality first and foremost. The second consideration is the amount of time to complete the project.

Based on this assessment, the traditional Design-Bid-Build method is not recommended due to the length of the entire process to project completion. In addition, the mix and size of the civil (field elements) and hardware/software elements of the project will likely not attract a technically qualified team given the low bid selection.

A Design-Build method may shorten the overall duration of the project, there are inherent risks that contractors will assume and build into their bids resulting in higher costs. Also, given the low bid nature of this method combined with the amount of hardware and software necessary, there are higher inherent risks to the quality of the overall system, i.e., hardware and software systems are typically not procured through a low bid process since the lowest bidder may equate to a lesser qualified contractor and/or system integrator. The amount of systems work on this project would likely not attract many qualified bidders. Firms that perform systems and software work are typically professional services firms who would not compete for low bid construction projects. Also, construction contractors would not want the risks inherent in the project for the comparatively small amount of construction work. For these reasons, a Design-Build procurement is not recommended.

Incentive based contracting is generally used in emergency situations and likely would not be approved for this type of project through Caltrans.

With Design Sequencing and the System Manager approaches, both have strengths from a project delivery stand point. The System Manager/Integrator approach will result in a higher quality hardware and software system given that BATA and Caltrans will be able to select and work with the preferred Integrator team resulting in better collaboration. However, the civil design will need to be completed prior to any field construction which does not shorten the duration of the schedule.

Design Sequence is a viable alternative for purely civil construction projects due to the schedule savings inherent in beginning construction before the design is complete. The Design Sequence approach may shorten the civil design and construction duration if phased properly, but introduces the risk of a less than qualified hardware and software integrator due to the low bid selection, i.e., system quality may be sacrificed with a lower price and shorter schedule. Caltrans has been piloting Design Sequencing as a delivery method. Currently, the results for the pilot projects are mixed with pilot projects not showing measurable cost or time savings. For this project, the systems/software work will be a major

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schedule driver due to the complexity of the system and the need for customized software and rigorous testing. As such, the schedule savings with Design Sequence does not provide as much of an impact to overall schedule. Design Sequence as a standalone method would require one contract with the civil construction contractor and the integrator as a subcontractor. This provides less control on the overall quality of the selected team.

Based on our team's assessment, the Combined/Hybrid approach is recommended. This approach combines the Design Sequence/CMGC for the civil construction elements with the System Integrator approach for the hardware and software elements. Under this approach, BATA and Caltrans will be able to work with the collaboratively with the preferred System Integrator on the hardware and software design while concurrently the civil construction elements are installed in phases. BATA would be able to contract with the System Integrator faster than under Design Build or Design Sequencing because it is a simple professional services agreement. Once the System Integrator is on board, they would provide input to the design to make sure it meets the needs of the system. BATA would have the ability to select the Integrator based on their approach and qualifications and the civil contractor based on fee and minimum qualifications. This approach would provide the highest quality system with the potential for a shorter project delivery due to concurrent field construction and an earlier start to software customization.

With the Combined/Hybrid approach for the SFOBB project the hardware and software required for the upgraded metering system would be selected using the System Manager method, which allows the System Integrator with the best proposal to provide the upgraded metering system. With the System Integrator on board, the civil improvements would be contracted using the Design Sequence method. This would require BATA to manage 3 contracts:

1. System Manager/Preliminary Civil Designer (65%)
2. System Integrator
3. Civil Contractor (Final Design).

Similar to the San Diego I-15 contracting approach, it is recommended that the civil design portion be completed with Caltrans playing an active role with the design team where they would have a direct impact on and ownership of the design. Caltrans also has the most knowledge and experience with existing conditions and utilities in the project area which would provide the maximum benefit for the design team. The Systems Manager would provide input to the design as the different phases are developed prior to construction.

Because of the complexity of the existing conditions, it is recommended that a design at or near the 65% stage be completed before the construction contractor is brought on board. The Design Sequence contracting method is being evaluated by Caltrans as a project delivery method and would require additional discussions with Caltrans to determine if this approach would be possible for the SFOBB project. Figure 1 below provides an illustration of the recommended project delivery approach and the various activities.

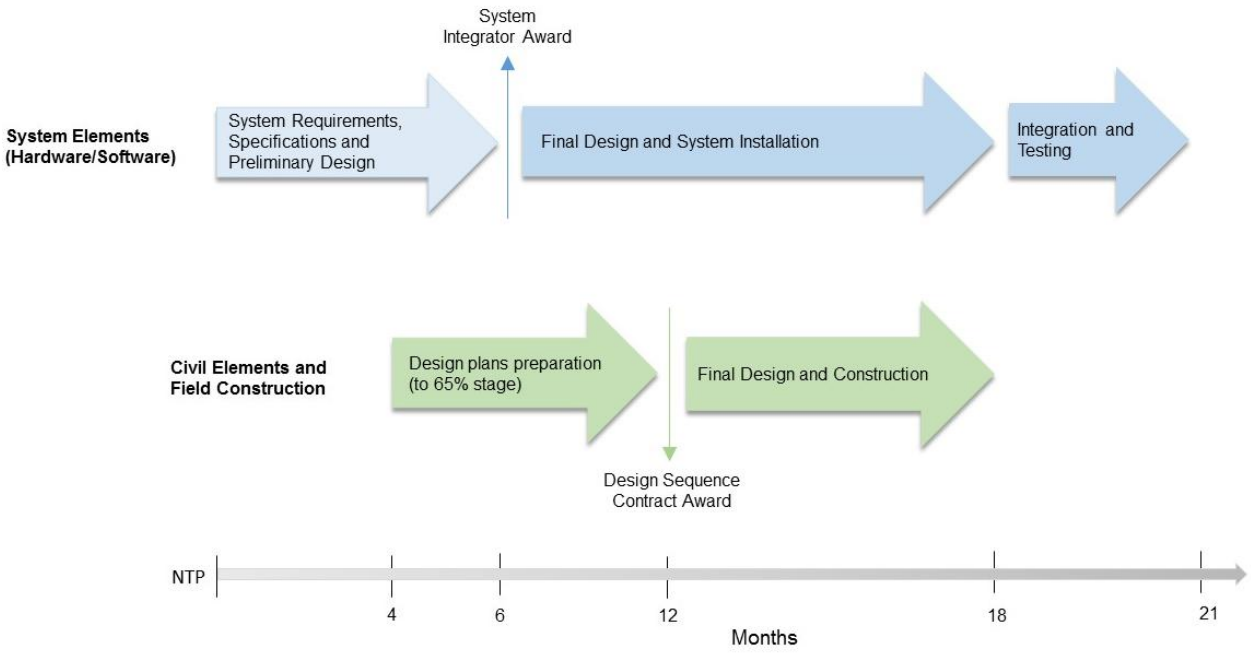

Figure 1: Recommended Combined/Hybrid Approach – System Integrator with Design Sequence