ALAMEDA
County Transportation Commission

7TH STREET GRADE SEPARATION AND PORT ARTERIAL IMPROVEMENTS PROJECT

System Engineering Management Plan

Prepared for Alameda CTC

August 13, 2018

Revision 4

7th Street Grade Separation and Port Arterial Improvements Project

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1. Introduction

1.1 Purpose of the Systems Engineering Management Plan (SEMP)

This document presents the Systems Engineering Management Plan (SEMP) that has been developed to guide the planning, design, procurement and deployment of Intelligent Transportation System and Technology (ITST) elements within and serving the Port of Oakland (Port) in Alameda County for the 7th Street Grade Separation and Port Arterial Improvements Project (the Project). The ITST implementation of the Project has been termed the Global Opportunities at the Port of Oakland Freight Intelligent Transportation System (GoPort Freight ITS).

When starting a complex project, managers must ask themselves how a quality product or solution would be delivered and what processes or methods would be employed to ensure a reliable, efficient use of stakeholder's time and funds. To address these questions, the California Department of Transportation (Caltrans) and the Federal Highway Administration (FHWA) recommend using the systems engineering methodology for implementation of complex projects. The SEMP is the top-level document that will guide the management of the systems engineering effort. The SEMP defines how the systems engineering portion of the project will be organized, structured and conducted and how the total engineering process will be controlled to provide a product that fulfills project objectives and requirements. The SEMP will be used by the Systems Engineering team members as a guide for the technical management of the GoPort Freight ITS. The format and content of the SEMP has been tailored from standardized outlines from Caltrans and FHWA to fit the GoPort Freight ITS – that guidance was tailored by Caltrans and FHWA based on the International Council on Systems Engineering (INCOSE)-approved standard for developing a SEMP: Institute of Electrical & Electronics Engineers (IEEE) Standard 1220-2005.

A Systems Engineering Process is a structured way of thinking about and defining a complex system. The Systems Engineering Process is an iterative approach to technical management, procurement, system design, product realization, and technical evaluation at each level of the system, beginning at the top and propagating those processes through a series of steps which eventually lead to a preferred system solution, and then continue through detailed design, deployment and initial operations. **Figure 1** shows a representation of the Systems Engineering Process called the VEE diagram. Note here that the top of the VEE diagram in **Figure 1** relates each of the systems engineering categories in the figure to the ITS engineering program effort showing at the top of the diagram (e.g., preliminary engineering, construction, etc.).

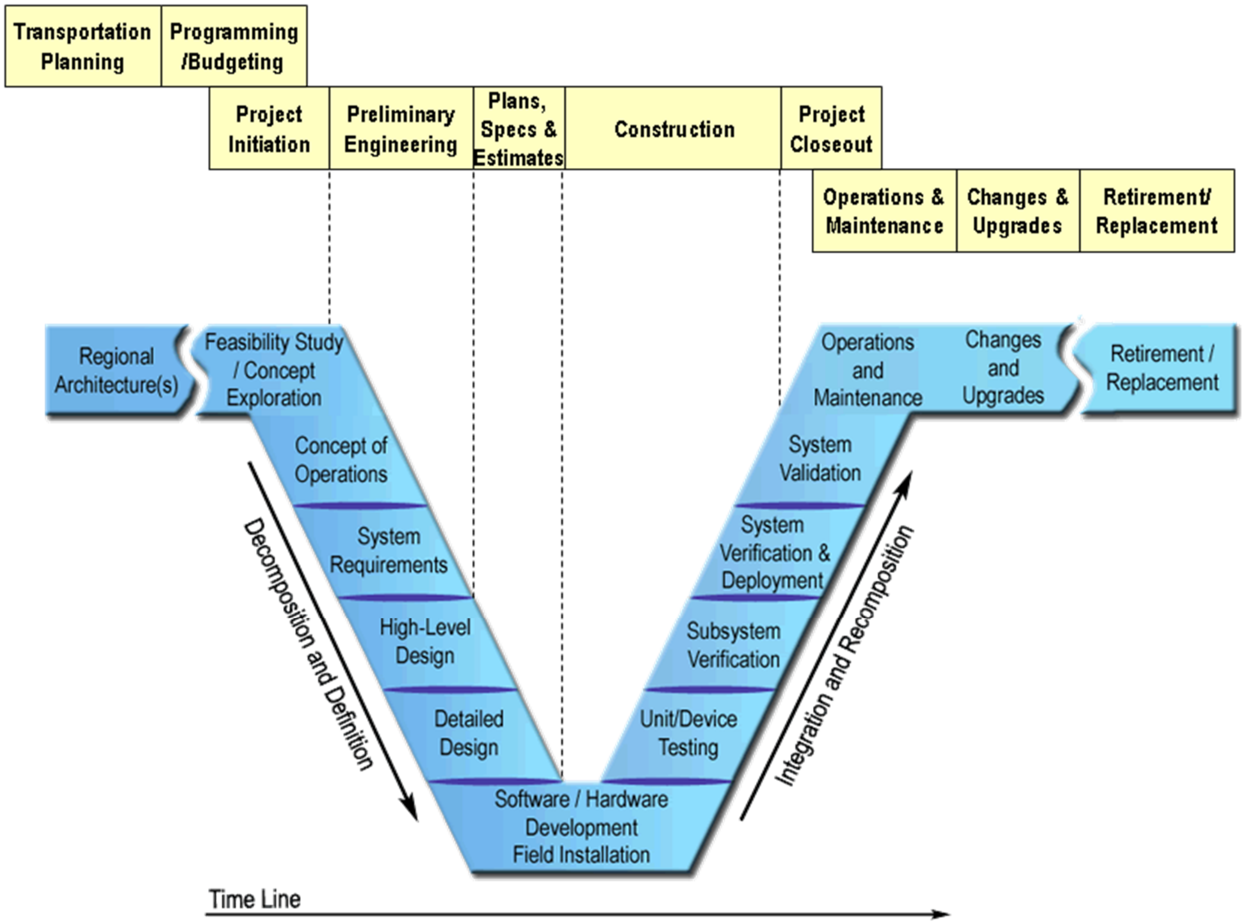


Figure 1: System Engineering Process

The SEMP document is typically developed early in the process as a supplement to a Project Management Plan (PMP). While the PMP addresses general project management details, such as project scope, participating personnel, schedule of activities, task scheduling and costs, the SEMP focuses on the technical plans and systems engineering activities that will be used to carry the project to its end. Its purpose is to detail the processes that will be used to support the design, implementation, integration, verification and eventual operation of the proposed system.

Since the SEMP is developed early in the life cycle of the project, it is generally developed with only a partial understanding of what is to be deployed. Available information typically includes only the results of the preliminary evaluations and needs assessments, as well as preliminary concept explorations that might have been conducted to assess project feasibility. As a result, several versions of the SEMP are typically released during the life of the project. For this version of the SEMP (March 2018), a **Concept of Operations (ConOps)** and an **ITST Master Plan** have been completed – these two documents together define the GoPort Freight ITS technologies and projects that will be deployed. More specifically, for the GoPort Freight ITS project, each of these documents will provide Alameda County Transportation Commission (Alameda CTC) and the Port management staff with the following guidance:

1. ConOps – Document developing an informed vision and use cases for the products and systems to be refined through stakeholder and agency input.
2. SEMP – Document outlining the systems engineering process for ITST procurements, projects and investment, and associated schedule of deployment.
3. ITST Master Plan – Document that evaluates the investments, funding sources, project priority and readiness, and recommended schedule of deployment.

1.2 GoPort Freight ITS Project Overview

Through a carefully designed process that develops stakeholder and user needs (see the GoPort Freight ITS ConOps), the GoPort ITS has been designed to deploy a suite of ITS and other information technologies to reduce emissions, fuel consumption, and environmental impacts, while improving mobility and relieving congestion in the Port and surrounding areas of Alameda County. This will be accomplished by the seamless integration proven technologies, such as changeable message signs (CMS's) and vehicle detection, as well as the development and enhancement of newer smart phone-based technologies. The integration and extension of these technologies will lead to an efficient and safer flow of freight, well-organized planning by trucking companies, coordination and communication among stakeholders, access to real-time data and information by the supply chain partners, and connectivity with roadway infrastructure; all of which result in benefits for all public and private stakeholders. Additionally, the initial deployment of GoPort Freight ITS elements is being planned to be deployed in time to substantially aid construction traffic flow in and out of the Port during the construction of the 7th Street grade separation infrastructure projects.

More specifically, the objectives of the GoPort Freight ITS project are to:

- Improve traffic information and management within the Port, its terminals and access routes
- Improve traffic observation, verification, and monitoring
- Enhance information sharing during an emergency or incident
- Improve transportation communications with the City of Oakland (City) and Caltrans
- Develop an ITS communication network that serves future needs
- Provide traffic management center (TMC) functionality at the Port for better traffic control, management and monitoring
- Reduce traffic congestion, truck idling and emissions
- Provide improved terminal wait time and turn time data information
- Improve traffic management during construction projects
- Minimize conflicts between transportation modes
- Improve the efficiency of goods movement within the Port (Agriculture is not the only benefactor but off-site warehousing and the trucking industry benefits too.)

To meet these objectives, the GoPort Freight ITS ConOps and ITST Master Plan documents define the specific technologies and operational framework. The identification and planning of the ITS and technology improvements in the ConOps were derived from outreach, research, and meetings conducted with the Project Development Team (PDT), ConOps Advisory Committee (CAC), Port staff, and interviews with key stakeholders in both the public and private sectors. Detailed descriptions of all of these stakeholder groups, including their role(s) in the GoPort Freight ITS, are presented in the ConOps.

Alameda CTC and the Port are the two primary stakeholders in the Project, and are providing the public sector management and coordination functions for the development and deployment of the GoPort Freight ITS. Supporting stakeholders include the following:

- Caltrans
- City
- Metropolitan Transportation Commission (MTC)
- Bay Area Rapid Transit District (BART)
- Union Pacific Railroad (UPRR)
- BNSF Railway (BNSF)
- Port of Oakland's Terminal Operators and Tenants
- Private Property Owners and developers
- FHWA

The GoPort Freight ITS focus is primarily aimed at traffic management and operations of arterial roadways in the Port environment, and regional traveler information dissemination to and from the Port. The proposed improvements have been grouped into two categories, each with increasing system sophistication:

- **Immediate**
  - Highest priority and need
  - Foundational to subsequent deployments
  - Addresses maintenance-of-traffic challenges during construction of the 7th Street grade separation and other construction projects within the Port
- **Future**
  - Features build upon the Immediate ITS package
  - Important to have but not essential, or cannot be completed in the immediate-term
  - “Nice-to-have” features
  - Technology may still be conceptual or not mature enough
  - Project elements were not identified by many stakeholders through user needs process

Table 1 summarizes the ITS improvement projects included in each category.

Table 1: Summary of GoPort Freight ITS Improvement Projects

Immediate	Future (Not included in Current Project)
• Communications (wireless fidelity (WiFi)) • Communications (Fiber) • Closed Circuit Television (CCTV) upgrade to High Definition (HD) • Queue Detection (QD) • Advanced Transportation Management System (ATMS) (includes centrally controlled signal system and adaptive traffic signal system) • Radio-Frequency Identification (RFID) readers • CMS's • Joint Traffic Management Center (TMC) / Emergency Operations Center (EOC) • Supplemental vehicle detection (SVD) • Center-to-Center (C2C) communication (includes interagency collaboration) • Advanced train detection system (ATDS) • Weigh-In-Motion (WIM) technology • *GoPort* Freight ITS information system/Application (app) • Basic smart parking system (BSPS)	• Freight signal priority • Enhanced *GoPort* Freight ITS information system/App • Dynamic lane control • Dedicated short-range communication (DSRC) • Enhanced smart parking system • Enhanced ATMS • Connected and autonomous vehicles

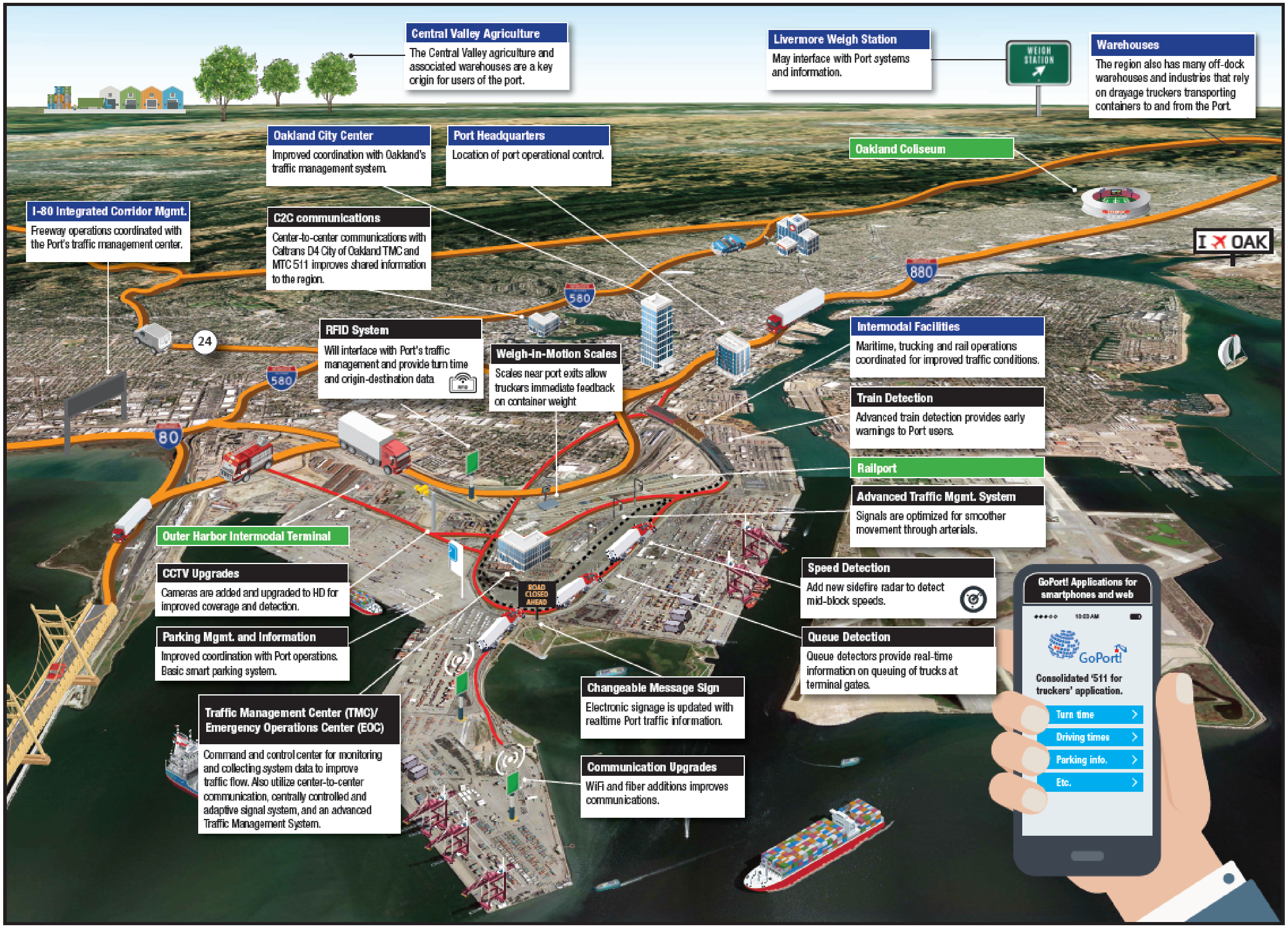
Source: 7th Street Grade Separation and Port Arterial Improvements Project Concept of Operations, November 2017.

Typically, in ITS projects, there are four main components; (1) the communications portion which is typically fiber-optic or copper cabling that provides a means for all the components to interface with each other, (2) the facilities that support project services and equipment, (3) the field devices that collect and disseminate all the data, and (4) an information data warehousing platform, which in this case is the *GoPort* app.

The Port's Joint TMC/EOC will serve as a key focal point of information gathering and dissemination for the system, and is where the GoPort Freight ITS application will be deployed. The Joint TMC/EOC's role has also been designed to facilitate Port operations management of Port recurring and non-recurring traffic incidents. Additionally, the system has also been designed to allow for eventual incorporation of connected and automated vehicle technology, which will support the collection and processing of Big Data that can support future real time ATMS, advanced traveler information system (ATIS) and performance monitoring applications.

Figure 2 provides an illustrative overview of how key elements of the GoPort Freight ITS system will be deployed. More details on the study area are presented in the ConOps.

Figure 2: GoPort Freight ITS System Overview



1.3 Document Outline

This SEMP is organized to serve as a reference document on the steps required to validate requirements and complete project specific System Engineering activities from concept definition through deployment. In some cases, it may be sufficient in its use as a stand-alone document to ensure compliance with the Systems Engineering Process for ITS projects.

This document is organized as follows:

- **Section 1** – Introduction
- **Section 2** – Project Planning and Control
- **Section 3** – Project and Systems Engineering Documentation
- **Section 4** – Transitioning Critical Technologies
- **Appendix A** – Application of System Engineering Process
- **Appendix B** – System Configuration Management Plan
- **Appendix C** – System Integration and Deployment Plan
- **Appendix D** – System Verification Plan
- **Appendix E** – System Validation Plan
- **Appendix F** – System Evaluation Plan
- **Appendix G** – System Operations and Maintenance Plan
- **Appendix H** – Glossary

2. Project Planning and Control

This section presents the proposed project planning and control guidance that Alameda CTC and the Port should implement to successfully deploy the GoPort Freight ITS, consistent with the systems engineering standards and best practices.

2.1 Project Delivery Organizational Structure

The overall GoPort Freight ITS organizational chart provided in **Figure 3** outlines management, coordination, advisory, engineering, and implementation roles – and their relationships to each other – of the key organizing entities of the system. It should be noted that Alameda CTC has contracted directly with the Systems Engineering Team prime consultant, Jacobs, and that all direction for the project development comes from Alameda CTC, with input from all other agencies and entities shown.

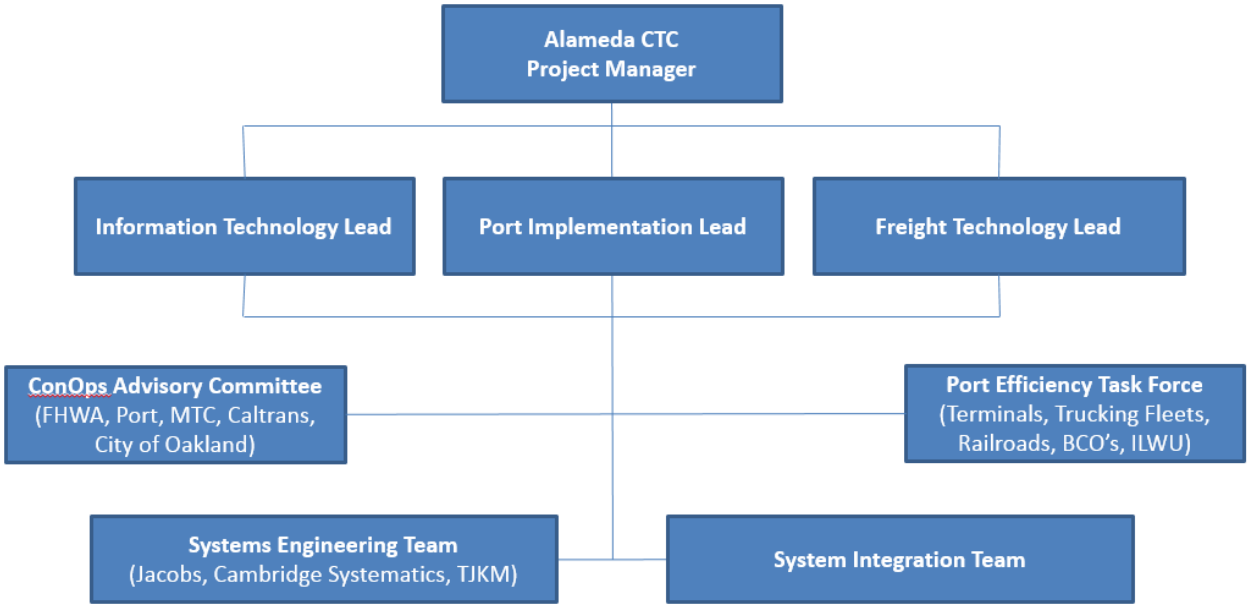


Figure 3: GoPort Freight ITS Organizational Chart

The following provides a description of each of these roles, with a focus specific to how each role affects the long-term development of the GoPort Freight ITS technologies:

- **Project Manager** – The Project Manager (PM) from Alameda CTC is responsible for complete technical management of the systems engineering, design, construction and initial operations (along with the Port) of the GoPort Freight ITS. The PM is thus responsible for managing all contractors involved in deploying GoPort Freight ITS (i.e. the Systems Engineering Team and System Integration Team), and is also responsible for overseeing the Port's implementation of GoPort. Additionally, the PM ensures continuous stakeholder engagement through involvement of the Port Efficiency Task Force (PETF) and the CAC.
- **ConOps Advisory Committee (CAC)**– The public sector CAC collaborative brings FHWA, the Port, MTC, Caltrans and the City to the table – to advise the PM and the three project technical leads (i.e. Port Implementation, IT Technology, Freight Technology), on all aspects of technologies that involve agency links to the system, including C2C communications.
- **Port Efficiency Task Force (PETF)** – The PETF is the Port operational stakeholder group, made up of Port staff, shipping lines, marine terminal operators (MTOs), trucking fleets, railroads, and labor unions (such as the International Longshore and Warehouse Union [ILWU]). The PETF will provide guidance and review of key project elements, including GoPort Freight ITS applications and Port ITS deployments. The PM and Port Implementation Lead shall manage the interface with the PETF.
- **Information Technology Lead** – The Information Technology (IT) Lead will serve as the Port's technical lead responsible for directing systems engineering, preliminary design, and pre-

deployment activities necessary to plan for the deployment of the IT elements of the GoPort Freight ITS that will be later implemented by the System Integration Team. This individual is Port agency personnel.

- **Port Implementation Lead** – The Port Implementation Lead is a Port PM responsible for managing and coordinating Port property coordination, Port staff activities and Port information/technology systems connectivity that will be necessary in deploying the GoPort Freight ITS technologies during system implementation. This role includes substantial coordination with the Systems Engineering Team and the System Integration Team. This individual is Port agency personnel.
- **Freight Technology Lead** – The Freight Technology Lead will serve as the Port's technical lead responsible for directing systems engineering, preliminary design, and pre-deployment activities necessary to plan for the deployment of the freight technology elements of the GoPort Freight ITS that will be later implemented by the System Integration Team. This individual is Port agency personnel.
- **System Engineering Team** – The Systems Engineering Team, led by Jacobs Engineering Group, supported by Cambridge Systematics and TJKM, performs systems engineering, preliminary design activities and pre-deployment coordination of the GoPort Freight ITS. This team performs all GoPort Freight ITS planning and design activities before construction, including the development of the ConOps, ITST Master Plan, and all design phases (35%, 65%, 95%, and 100%). Work conducted by the Systems Engineering team is coordinated with all other 7th Street Grade Separation design activities. Following construction, the System Engineering Team is responsible for ongoing systems engineering activities, including engineering management support to Alameda CTC and the Port, review of the System Integration Team activities during the deployment phases (i.e. conducts engineering/test/deployment reviews) developing and implementing system performance monitoring, and continuous technical review and reporting. Additionally, the Systems Engineering Team shall provide guidance to the System Integration Team during the complex deployment of initial elements of the GoPort Freight ITS during the ITS construction phase. The Systems Engineering Team will also provide input to Alameda CTC on the scope for the System Integration Team procurement. Systems Engineering Team contractor team members shall be precluded from being on the System Integration Team to avoid conflict of interest.
- **System Integration Team** – The System Integration Team contractor (contractor/consultant to be procured in the future at the completion of the design documentation) will procure the equipment as indicated in the design, develop the GoPort Application, conduct integration and testing activities, and deploy the integrated system of GoPort Freight ITS project technologies. The System Integration Team will include all necessary subcontractors and vendors to deploy the technologies. System deployment activities will begin after a procurement activity, which is expected to occur after the System Engineering Team completes the 100% FITS Design Plans.

2.2 Project Phases

The four project phases are defined as follows:

- **Planning and Preliminary Systems Engineering Phase.** Starting with a rigorous user needs assessment, this phase of the project developed the overall technical and project conceptual framework that defined the GoPort Freight ITS system in enough detail such that design / plans, system requirements, specifications and estimates (PS&E) activities could commence in the subsequent phase. This phase of the project began with the development of the ConOps, continued with the development of the SEMP, and is now concluding with the development of ITST Master Plan. As of the publication of this version of the SEMP (March 2018), this phase has been nearly completed, pending final acceptance of the ConOps, SEMP and ITST Master Plan documents.[1]
- **System Design Phase**. This phase includes developments of PS&Es, and graduating levels of detail: 35%, 65%, 95% and 100%. The PS&E's will identify the system requirements. This phase concludes with the development of a technical scope and performance metrics for the System Integration Team contractor(s), which will guide construction in the next phase – this phase thus prepares the complete PS&Es required to advertise and award the Project for construction. All work in this phase is coordinated as needed with work being done on other 7th Street Grade Separation projects. All work in this phase is guided by a Quality Assurance / Quality Control (QA/QC) Plan and is conducted based on all applicable design standards (e.g., Port design criteria, California Public Utilities Commission (CPUC) standards, Construction Specifications Institute (CSI) standards). All technical work in this phase is implemented by the Systems Engineering Team.
- **Construction Phase**. This phase includes the development, implementation, integration, testing, verification, validation and deployment of all of the ITS Technology Improvement Projects (see **Table 1**). This includes all hardware and software, including both vendor "commercial-off-the-shelf" hardware and software, as well as all hardware integration, and development of all customized software that will be necessary to integrate all of the technology projects into the functioning system. The focus on this construction is expected to be on the "Immediate" technologies summarized in **Table 1**; furthermore, the construction will be phased such that an initial set of core functions of the GoPort Freight ITS (Joint TMC/EOC, RFID, Communications (Fiber), Queue Detection, ATMS, CMS, and GoPort App) is in place in time to support management-of-traffic in and out of the Port during the 7th Street grade separation infrastructure construction. The construction phase work is conducted by the System

[1] Note that this phase of the project also included the development of successful grant applications to the United States Department of Transportation's (USDOT's) - Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Program and Department of Homeland Security (DHS) - Port Security Grants Program, which were developed based on the ITS Technology Improvement Projects (see Table 1) from the ConOps and ITST Master Plan. All technical work in this phase is implemented by the Systems Engineering Team

Integration Team contractor, who will begin work in this phase based on a new procurement, with a scope that is based on the PS&E output of the previous phase. Systems Engineering Team work during this phase includes: addressing contractor questions and RFIs; conducting any necessary design revisions; providing input or feedback to tests; coordination of work on other 7th Street Grade Separation projects; developing the system performance evaluation plan; working with the System Integration Team to develop automated performance data and archiving, guidance to the System Integration Team during the complex deployment of initial elements of the GoPort Freight ITS during the 7th Street grade separation construction phase; and continuous technical review and reporting (e.g. progress and annual reports to USDOT)

- **Initial Operations Phase**. The Initial Operations phase includes two primary elements: (1) Initial Operations of the GoPort Freight ITS that will be deployed in time to support management of traffic in and out of the Port during the 7th Street grade separation infrastructure construction (i.e., Joint TMC/EOC, RFID, Communications (Fiber), C2C, CCTV, QD, ATMS, CMS, and GoPort App); and (2) remaining and upgraded GoPort Freight ITS "Immediate" elements that will deployed to enhance the Freight ITS (i.e., SVD, ATDS, BSPS, WiFi, and WIM). Additionally, under the ATCMTD grant program, the GoPort Freight ITS is to be initially operated continually for at least one year, with system performance monitoring to be continuously conducted, with the results being reported back to USDOT. For this phase, the System Integration Team is tasked with ensuring robust technical operation of the system for the initial three years (i.e. warranty, Help Desk, necessary upgrades based on user feedback), and the Systems Engineering Team is tasked with continually monitoring and evaluating the system, including providing feedback and input into automated data collection, archival and performance analysis system, and developing reports on the system performance and user experience to support reporting to USDOT and the project stakeholders.

2.2.1 Project Schedule

The project schedule for the development, construction and initial operations of the GoPort Freight ITS is presented in **Figure 4**.

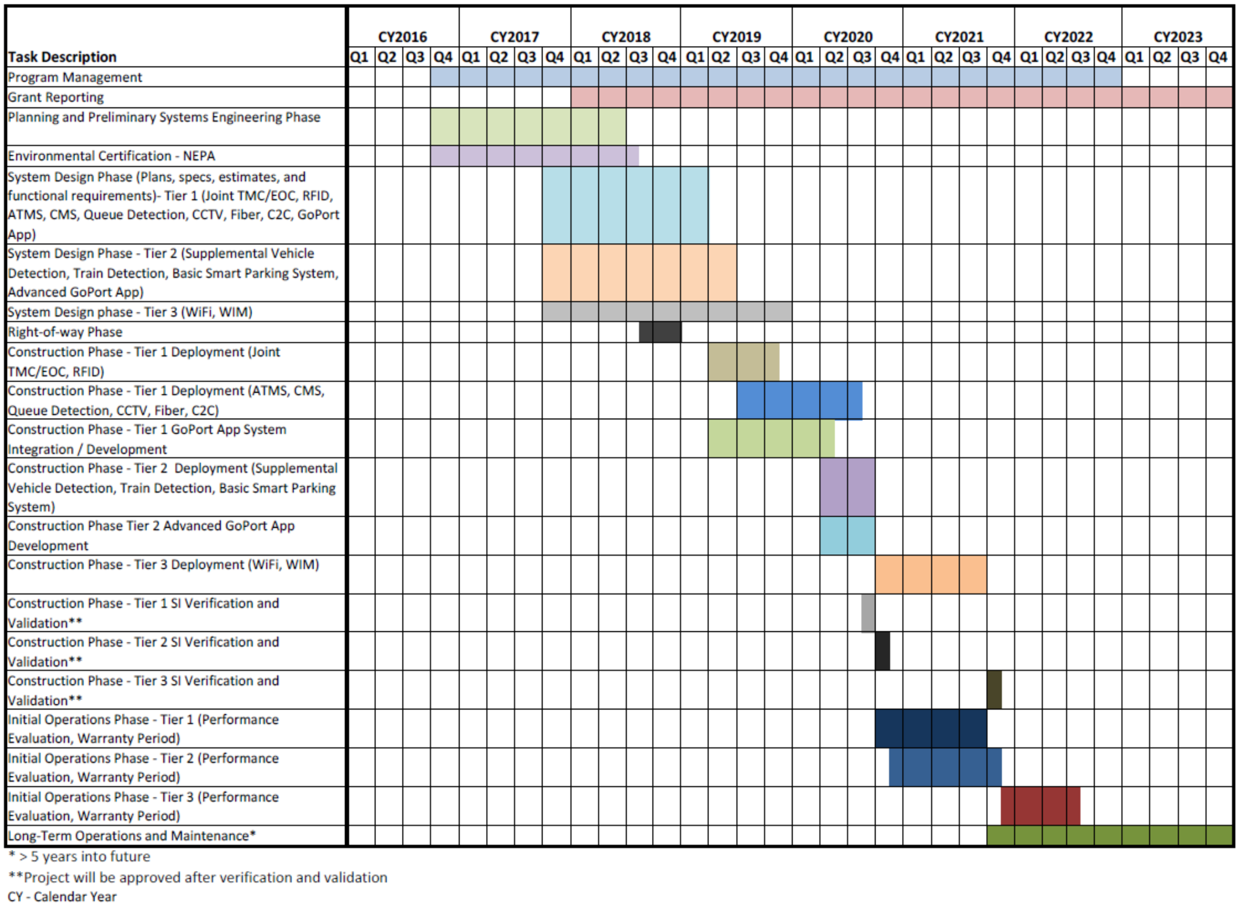


Figure 4: GoPort Freight ITS Project Schedule

3. Project and Systems Engineering Documentation

This section presents the key systems engineering and major project documents that should be developed across the four phases of the GoPort Freight ITS project. It also covers the deliverable review process.

3.1 Deliverables Guidance

The identification and description of each required document is presented below in

Table 2. For each deliverable, the table provides a brief Purpose/Content description, and also identifies the entities responsible for drafting these documents. Many of these documents will be developed in stages. A preliminary document outlining the framework may be developed in early stages, with multiple updates and revisions during the course of the project implementation as additional information becomes available.

Table 2: GoPort Freight ITS Project Deliverables

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
Planning and Preliminary Systems Engineering Phase						
Concept of Operations	1	7GSP_ConOps_Final-R3_180813	08/13/18	Being updated to address FHWA feedback. Updated version to be submitted along with 65% PS&E in July 2018.	Document identifying the stakeholders and user needs for the GoPort Freight ITS project, describing how the proposed concept may improve traffic conditions within and accessing the Port, presenting the high-level technical conceptual framework for how the system will operate, and developing illustrative operational scenarios that describe how users will access and benefit from using the system in response to Port operations and traffic conditions. The ConOps was developed based on FHWA and Caltrans Guidance, which are based on IEEE Standard 1362-1998. Note that this document has been completed and is available under separate cover from Alameda CTC.	Systems Engineering Team
ITST Master Plan	2	7SGSP_ITST_Master_Plan_Draft-R1_171102.pdf	11/02/17	Draft Final completed. Minor edits remaining..	Document expands upon the ConOps. It describes the basic ITS architecture and communications network for immediate deployment for the GoPort Freight ITS projects using commercially available technologies, and provides a backbone for future deployment of Freight Advanced Traveler Information Systems (FRATIS), Connected Vehicles (CV) technologies, and other feasible technologies. The report documents the recommendations for deployment types based on a technology scan that includes costs and the reasons why projects are proposed to be moved forward. This includes rationale for investment using benefit-cost analyses and project prioritization. It includes high-level system requirements. It also includes an overview of funding sources. The Plan details the deployment of various ITS strategies into one integrated ITS system for an improved capacity for proactive and reactive management in and around the Port. Note that this document has been	Systems Engineering Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					completed and is available under separate cover from Alameda CTC.	
System Design Phase						
Project Management Plan (PMP) – Systems Engineering Team	3	PEP-PPM-Rev2	6/19/18	Complete and final.	A document that defines scope, schedule and budgets; and includes a Communication Plan that identifies point of contact and delineates communication protocols, change management, risk management, QA/QC, and health and safety protocols. The plan will include work breakdown structures (WBS), and will also delineate how the project will be supervised, coordinated and monitored for preparation of deliverables in conformance with the Port, Alameda CTC, Caltrans, City, and other applicable standards and policies.	Systems Engineering Team
Detailed Critical Path Method (CPM) Schedule	4	GoPort Program Delivery Schedule	7/16/18	Complete and updated as needed.	A detailed CPM schedule in Microsoft Project format to be submitted on a monthly basis. Also to include a four-week "look ahead" horizon schedule that we be presented at each monthly PDT Meeting.	Systems Engineering Team
Quality Assurance/ Quality Control (QA/QC) Plan	5	ACTC_Quality Management Plan_Draft	10/28/16	Complete and final.	The plan will outline the minimum standards, expectations and procedures required for all deliverables during the system design phase. The QA/QC Plan will be developed along with sub-consultants' input and and they will be required to adhere to the guidelines included therein.	Systems Engineering Team
Risk Management Plan/Risk Register	6	Master_7SGSP_Risk_Register	5/3/18	Complete and updated as needed.	The Risk Management Plan will cover recommended processes and tools for planning, identifying, monitoring, analyzing, and mitigating potential risks. The Risk Register will be the tool that will implement the Risk Management Plan – it will be a living document that will be updated quarterly, and will track all identified project risks, and will also track any implemented risk mitigation strategies.	Systems Engineering Team
Plans for 35% PS&E (i.e., high-level design)	7	20180402_FITS Final 35% Design	04/02/18	Complete and final.	Documents the preliminary, high-level design and set of plans for the GoPort Freight ITS. This document provides a description of the system components defined in the high-	Systems Engineering Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					level architecture; further identifies system requirements; itemizes the system components; decomposes the system to be developed into high-level components and interface based on the identified system requirements; and defines how the overall individual system components will communicate with each other. It also provides initial engineering plans that will support eventual construction of the system. The PS&E documentation must conform to applicable Port design criteria and standards and other applicable standards of the affected owner agencies, CPUC regulations, policies, procedures, manuals and adopted standards effective as of April 2018 as well as ITS standards, including compliance with FHWA requirements. Where applicable, specifications will also be based on the CSI format.	
Plans for 65% PS&E (i.e., detailed design)	8	n/a	n/a	Currently being developed due for submittal in August, 2018.	Builds on the 35% design and creates and documents a refined, detailed design and set of plans for the GoPort Freight ITS. This document provides a detailed description of the system components defined in the high-level architecture; further identifies system requirements; itemizes the specific items that the system components must be able to do; decomposes the system to be developed into high-level components and interface based on the identified system requirements; and defines how the overall individual system components will communicate with each other. It also provides engineering plans that will support eventual construction of the system. The PS&E documentation must conform to applicable Port design criteria and standards and other applicable standards of the affected owner agencies, CPUC regulations, policies, procedures, manuals and standards effective as of August 2016 as well as ITS	Systems Engineering Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					standards, including compliance with FHWA requirements. Where applicable, specifications will also be based on the CSI format.	
Plans for 95% PS&E (i.e., detailed design)	9			Will be developed in future. Currently scheduled for November 2018 and March 2019 dependent upon PS&E package.	Builds on the 65% design and creates and documents a near-final detailed design and set of plans for the GoPort Freight ITS.	Systems Engineering Team
Plans for 100% PS&E (i.e., detailed design)				Will be developed in future. Currently scheduled for December 2018 and April 2019 dependent upon PS&E package.	Provides the final detailed design and set of plans for the GoPort Freight ITS that will be sufficient for Alameda CTC to use in creating a scope for the construction phase, which will support the selection of construction contractors and a System Integration Team to construct the system.	Systems Engineering Team
Cooperative Agreements				Will be developed in future. Anticipated submittals to coincide with PS&E	Documents detailing the operational responsibilities of individual project stakeholders and recording their agreements to participate and support the GoPort Freight ITS project, such as Project Charter, memoranda of understanding (MOUs), and other official signed documents.	Alameda CTC, City, Caltrans, MTC and Port

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
				submittals.		
ATCMTD Annual Report to USDOT #1				Will be developed in future.	Prepare the required report to USDOT that documents progress on the development and deployment of the funded technology applications, and documents performance of the system and measured benefits (later in the deployment).	Systems Engineering Team
Construction Phase						
Project Management Plan (PMP) – System Integration Team				Will be developed in future by Sys Int prior to construction.	A document that defines scope, schedule and budgets; and includes a Communication Plan that identifies point of contact and delineates communication protocols, change management, risk management, QA/QC, and health and safety protocols. The plan will include WBS's, and will also delineate how the project will be supervised, coordinated and monitored for preparation of deliverables in conformance with the Port, Alameda CTC, Caltrans, City, and other applicable standards and policies.	System Integration Team
Outreach and Stakeholder Communication Plan				Will be developed in future by Sys Int prior to construction.	Document discussing the communications strategy for the System Integration Team to interact with all relevant project stakeholders during the construction phase and the initial operations phases. A user/stakeholder feedback protocol should be presented. This document also defines Help Desk functions/operations.	System Integration Team
System Configuration Management Plan				Will be developed in future by Sys Int during construction.	Document describing how changes made to the system components will be tracked to ensure that all developed documents remain up-to-date, and describe the System Engineering approach and methods to manage the configuration of the system's products and processes. This plan will also address the QA/QC of any documentation. This plan will describe how the Systems Engineering team will maintain consistency with the requirements baseline throughout the project. The plan will focus on evaluating, coordinating, approving and implementing changes to the	System Integration Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					components that are used to construct and maintain systems. The plan will also identify goals for the GoPort Freight ITS that are required to keep the system's performance, functionality and physical attributes consistent with its requirements, design and operational information.	
System Specification				Will be developed in future by Sys Int prior to construction.	This will be the key engineering specification document from the Systems Integration Team contractor that will define the plan for deploying and operating the system, based on the 100% PS&E from the previous phase. It is recommended that this document include the following sections; furthermore, it is recommended that the elements of this document be included as part of the System Integration Team's procurement process (i.e., requiring submitters to propose a technical approach for each of the areas below): 1) Final System Detailed Design and Architecture – the proposed formal specification of the final system detailed design and architecture, noting and justifying any changes made from the 100% PS&E design and plans. 2) System inventory and Bill of Materials (BOM) describing the various system components to be developed, integrated and deployed. 3) Data Dictionary providing a description of all the data used by or exchanged between system components. 4) System Deployment and Integration Plan defining how different system components will communicate and work together in an integrated environment, while also ensuring that a fully integrated operating system is deployed that meets all of the functional requirements. This plan will describe the sequence of activities for integrating different subsystems into a complete and functioning system. The plan will document details on	System Integration Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					how the ITS systems will be installed, tested and implemented for operational use. 5) Test Plan describing methods for testing both the system and subsystems. 6) System Verification Plan that describes how system users will verify that the developed system meets the project functional requirements and follows the design. The System Verification Plan will organize the system functional requirements into test cases and include specific steps for carrying out a list of procedures to test each requirement. The plan will identify or define how each of the requirements will be tested within the system and sub-systems, who will perform the testing, where the test will be performed, what items are required to be performed as part of the test, and what to do if the test fails. 7) System Validation Plan will provide various system validation procedures that will be implemented to ensure that the deployed ITS system does what it was intended to do, as defined in user needs. The validation plan will address what, how well, and what conditions the GoPort Freight ITS system will need to perform to a given outcome – this process performs a comparative assessment and confirms that the stakeholders' needs were met. Where variances are identified, they will be recorded and guide corrective actions to meet the stated requirements. Corrective action, among other possible actions, may include re-design, component reconfiguration or software revisions. 8) Data Management Plan defining how data will be stored and accessed (including a description of how data would be organized to facilitate queries in real-	

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
					time environments and subsequently stored and organized in a data warehouse). 9) Operation and Maintenance Plan describing the roles and responsibilities of system users, as well as the maintenance processes. 10) Training Plan defining the training requirements and delivery media, based on user roles. 11) Security Plan defining security measures to be implemented, from both a physical (hacking) and personal (administrative privileges based on user roles) perspective.	
System Specification Formal Review				Will be developed in future by Sys Int during construction.	A formal in-person review of the System Integration Team's System Specification Testing. Includes a scoring checklist and guide for participants to conduct the review. The Systems Engineering Team shall develop the processes for this review and shall facilitate the review meeting(s).	Alameda CTC, Port Systems Engineering Team & System Integration Team
System Evaluation Plan				Will be developed in future by Sys Eng prior to construction.	Document identifying how the operational benefits of the GoPort Freight ITS project will be evaluated. The Evaluation Plan will include key performance goals and objectives, supporting performance measure metrics, the evaluation approach and test plans, and schedule. To the extent possible, desired performance metrics that the system can generate will be defined in the functional requirements and implemented for continuous measurement availability during the deployment and monitoring phase. This plan must also work symbiotically with the System Integration Team's approach to data management.	Systems Engineering Team
Evaluation Data System Development				Will be developed in future by Sys	Based on the approach defined in the System Evaluation Plan, the System Engineering Team and System Integration Team shall collaborate on collecting and analyzing system	Systems Engineering and

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
				Eng and Sys Int near end of construction.	performance data from the GoPort Freight ITS.	Integration Teams
ATCMTD Annual Report to USDOT #2 and #3				Will be developed in future by Sys Eng near end of construction.	Prepare the required report to USDOT that documents progress on the development and deployment of the funded technology applications, and documents performance of the system and measured benefits (later in the deployment).	Systems Engineering Team
Initial Operations Phase						
System Training				Will be developed in future by Sys Int near end of construction completion.	The Systems Integration Team shall implement its training program that it had defined in the System Specification document. This will include tailored system training for all anticipated public and private sector users of the system.	System Integration Team
Help Desk				Will be developed in future by Sys Int near end of construction completion.	A Help Desk shall be employed by the System Integration Team to provide assistance for users of the system (e.g. system administration issues and troubleshooting)	System Integration Team
Operations and Maintenance Plan				Will be developed in future by Sys Int and Sys Eng teams near end of	The Operations and Maintenance Plan will include procedures and requirements for operating and maintaining the devices and/or system. The plan will include a planned annual schedule of maintenance, a long-term schedule of planned replacements/upgrades, and a forecast of annualized hardware, software licensees and labor resources	Systems Integration and Engineering Team

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
				construction completion.	required to maintain the system over the long-term.	
Evaluation Data System Operations				Will be developed in future by Sys Eng and Sys Int during initial operations.	Using the Evaluation Data System developed in the construction phase, system data will be collected, archived and evaluated during the Initial Operations Phase, and will be continuously archived to support performance evaluation.	Systems Engineering and Integration Teams
Evaluation Report				Will be developed in future by Sys Eng during initial operations.	Document identifying the operational benefits provided by the GoPort Freight ITS project to the operators of individual transportation systems and travelers. This will include quantitative system performance evaluation results derived from the Evaluation Data System; and cost and benefit data shall be collected/estimated; key participants shall be interviewed to determine if the results are meeting the intended user needs and functional requirements and any other issues or benefits. Where variances are identified, they will be recorded and guide corrective actions to meet the stated requirements. Corrective action, among other possible actions, may include re-design, component reconfiguration or software revisions. Additionally, lessons learned during the development, deployment and operation of the GoPort Freight ITS shall be synthesized and presented.	Systems Engineering Team
System Demonstration Event Planning				Will be developed in future by Sys Eng and Sys Int during initial operations.	It is anticipated that several system demonstrations will be conducted during the initial operations phase. This guidance document and set of outreach materials will support such demonstrations	Systems Integration and Engineering Team
ATCMTD				Will be	Prepare the required report to USDOT that documents	Systems

Deliverable	Document #	File Name	Latest Version Date	Document Status	Purpose/Content	Responsible Party
Annual Report to USDOT #4				developed in future by Sys Eng during end of intial operations.	progress on the development and deployment of the funded technology applications, and documents performance of the system and measured benefits	Engineering Team

3.2 Deliverable Review Process

The following steps are necessary for appropriate review and approval of all System Engineering documents developed throughout the GoPort Freight ITS project duration.

- Initial review by Technical Team Lead – Review of the document by the team lead responsible for the development and writing of the document. This review will focus on the technical completeness of the document.
- Review by GoPort Freight ITS Project Management Team – General review of the document by the Port's PM and staff, including editorial review to ensure that the document adheres to specific presentation guidelines and is free from typographical errors.
- Review by Caltrans – Review of the document by Caltrans PM and, if relevant, Caltrans staff who may have interest in the details contained in the document.
- Review by Alameda CTC – Review of the document by Alameda CTC PM and staff, and potentially by MTC, to ensure that the documents support regional interests and objectives.
- Review by FHWA – Review of document by FHWA PM to ensure that grant requirements and required system engineering procedures are being met.
- Review by Stakeholders – Review of the document by stakeholders who may have an impact due to the GoPort Freight ITS.

Although an elaborate list and process have been provided here, not all documents will require the level of review and approvals shown. Depending upon the nature of updates and revisions, some documents may not need to be reviewed by all entities and stakeholders.

The document review may be conducted using one or more of the following methods:

I. Individual review of the document with comments provided using "Track Changes" mode or in a list format
II. Feedback via one-on-one or group meetings
III. Larger group meetings involving multiple stakeholders

Any necessary approvals for the revisions can be granted by default (e.g. if no comments are received by certain date), oral agreements at meetings, or more formal agreements with a signature.

3.2.1 Applicable Standards for Design and Engineering Documentation

All work products and deliverables will be prepared in accordance with the Port design criteria and standards and other applicable and adopted standards of the affected owner agencies, CPUC regulations, policies, procedures, manuals and standards effective as of April 2018 as well as ITS standards, including compliance with FHWA requirements.

With the exception of equipment that is required to be specified to Caltrans or City adopted standard specifications, specifications will be based on CSI formats inasmuch as possible and utilize the latest state of technological standards for deployment. For items where a CSI standard does not exist, the CSI format and layout will be utilized to prepare new specifications required to meet the needs of the project.

3.2.2 Submittals

All submittals of final technical reports and drawings will be provided electronically in Adobe Acrobat PDF format and source files in Microsoft Word, Excel, PowerPoint, or Project format, as well as, Autodesk AutoCAD 2015 on CD/DVD or as otherwise directed by Alameda CTC. All draft documents will be submitted in Microsoft Word and Adobe Portable Document Format (PDF) for agency review and comment.

3.2.3 Document Repository

Both the Systems Engineering Team and the System Integration Team will host an online document repository system (e.g. ProjectWise server) for Stakeholders to review and share non-sensitive project related information.

4. Transitioning Critical Technologies

4.1 Critical Technologies

As technologies mature and evolve, it is essential to make a concerted effort to use technology-neutral language when defining system operational concepts and requirements. Specific functional, usability, performance, and interface requirements should dictate technology at the time of implementation. Describing concepts and requirements thusly helps to give the relevant documents longer life, requiring few modifications, and keeping the doors open to new and innovative solutions that inevitably arise over time.

The major critical technologies that will be deployed on this project are:

- *GoPort* information system/App - The *GoPort* traveler information app will be a multi-platform system (e.g., web, mobile app, e-mail, etc.). It will be a consolidated portal of useful truck information and web tools. It will disseminate static and real-time Port messages and information regarding travel times, parking, incidents, wait times, terminal turn times, terminal information, etc. This application will be developed specifically for this project leveraging standard application frameworks that would provide a fundamental structure for the Port environment.

- CMS's - Informs truckers on regional conditions as they leave the Port, incidents or Port information as they enter. CMS's will be fiber connected and connectivity to the Joint TMC/EOC will allow access and control by the traffic management system.
- Joint TMC/EOC - New ITS elements will integrate with existing security equipment, functions, and emergency operations center. The TMC/EOC will be a "home" for control of the ATMS and where standard operating procedures (SOPs) will be created and centered around. The TMC/EOC provides basic communication/connection to other public agencies to coordinate transportation and incident management (e.g., Caltrans, California Highway Patrol (CHP), City, MTC, U.S. Coast Guard (USCG), and Department of Homeland Security (DHS)).
- Communications (WiFi & Fiber) – This will complete the existing fiber network and will set the foundation for connection and control of all other ITS elements. WiFi capabilities will be added as a backup communication system and a means for addressing cellular dead spots – a major issue in parts of the Port. These communications improvements will offer amenities to truckers within the Port and will enhance Port staff capabilities to transmit and receive "last mile" data.
- C2C communication – This consists of deploying new communication interfaces among the public sector agencies and establishes C2C policies. This is essential for signal control and messaging and dissemination of real time regional travel information.
- CCTV upgrades to HD - Upgrade the existing CCTVs to HD, filling surveillance gaps and deploy vehicle video detection software. Cameras can address surveillance and traffic needs simultaneously but HD imaging is needed for appropriate traffic analysis. New poles for cameras focused on vehicle detection will be installed as well as a new stretch of cameras and poles on Maritime between 7th Street and Middle Harbor Road.
- RFID readers - The existing RFID network will be expanded to allow the Port to improve the accuracy and reliability of the calculation of turn times and acquire refined information on truck movements. Allows growth into FRATIS or other technology deployments.
- Queue detection - Add automatic queue detection in the form of "side fire" radar and video detection. Equipment will be located at known hot spots.
- Advanced train detection system - Non-intrusive train detection can be used to provide warnings and traveler information on CMS's and the *GoPort* app. Eventually, rail detection can be integrated with traffic signal systems.
- ATMS (includes centrally controlled signal equipment upgrades) - Upgrade existing traffic signal system to allow connectivity and control by the joint TMC/EOC. Equipment will be connected to the same fiber loop. Signal controllers with networking equipment will be installed. Will involve coordination with the City and Caltrans. Set up software to receive traffic information, control messages, and control traffic signal systems. Software should be upgradeable to allow further automation and enhancements (i.e. adaptive signal system). Allows for potential connections/collaboration of operations with other public sector equipment and systems.
- Adaptive signal system - The ATMS software will be upgraded to allow for an adaptive traffic signal system control. Adaptive signal control, unlike conventional pre-programmed time-of-day

signal timings, utilizes intersection vehicle detection and sensors to adjust the timing of red, yellow and green phases and for each approach as well as overall cycle lengths to accommodate changing traffic patterns and reduce congestion by improving vehicle progression. This may include the addition of more video based vehicle detection cameras or other sensors, as necessary.

- Supplemental vehicle detection (speed) - “Side fire” radar is useful for nonintrusive midblock detection and would not only fill in gaps from video detection, but also provide speed information.
- WIM - This WIM scales would be located on Port property as a courtesy to trucks leaving the Port with new containers to be able to weigh their cargo. Can be done at slow speeds but smooth road surface is needed. Potential WIM information sharing and coordination with CHP may occur for connectivity of information.
- Basic smart parking system - Provide a system that monitors parking availability that can be shared via the *GoPort* app and CMS’s.

There are two key synthesizing elements of these 13 technology deployments: a “GoPort” TMC/EOC; and the “*GoPort* Freight ITS Information System/App”:

1) The GoPort TMC involves the expansion of the Port’s EOC to include Port-specific TMC capability, consistent with staffing levels at the current EOC. The effectiveness of the joint TMC/EOC will be enhanced by other technologies proposed for project deployment, including additional surveillance and detection equipment, integration of existing databases, improved data analytics, provision of detailed freight-specific information through mobile devices (e.g. predictive terminal wait times, container availability through *eModal* (an online gateway that provides MTO information on container availability) link, customized alerts, internet applications, as well as roadside CMS’s. Regional data sharing through C2C Communications with Caltrans District 4 will also be featured, as well as connectivity with MTC’s existing *511* traveler information system.
2) The *GoPort* Freight ITS Information System/App will consist of a database that will integrate with the TMC to synthesize, both real-time and historical data, on Port traffic, truck access, major travel routes, incidents, terminal queues, parking conditions, rail crossing information, ship arrival, container availability, and other key information. Additionally, multiple user apps (web and mobile) will be developed on the platform for multiple user types – including trucking dispatchers and drivers, MTO staff, railroad operations staff, Port operations staff, and public-sector operations staff.

4.2 Evaluation and Implementation of Critical Technologies

4.2.1 Deployment Evaluation of Critical Technologies

As part of the ITST Master Plan development process, in order to effectively rank the priority of ITST deployment, a multi-attribute decision-making model was developed by the Systems Engineering Team. The model includes quantitative elements where available, but also incorporates qualitative assessment of potential benefits and obstacles. The end result is a listing of all ITST projects ranked from the highest relative priority to the lowest, reflecting both quantitative and qualitative inputs and the goals of the Port.

The prioritization process includes the following key inputs:

- **ITST deployment projects -** Each of the projects is evaluated individually to generate its relative priority.
- **Criteria for prioritization -** These are measures of the different potential value or benefit areas that should be considered for each project. Criteria are selected to balance the benefits and costs of several different opportunity areas for improvement.
- **Weights -** Each criterion receives a weight reflecting its relative importance in the prioritization process. All of the weights together add up to 100. The weights were decided based on considered relative importance to the system stakeholders. After several iterations, the CAC decided on equal weighting of all criteria.
- **Score -** The project team developed draft recommendations within each criterion for every project, assigning a score of low, medium-low, medium, medium-high, or high. These scores correspond to a numerical value. A project which scored high in numerous criteria, especially those that are highly weighted, would be of high relative priority.

Next, the following criteria are used for the prioritization process. They are described briefly along with the measures (some criteria have two or three effective measures) used to determine their value. It should be noted that the stakeholder group elected to not have benefit/cost ratio as one of the criteria.

- **Project readiness** - Projects which are ready for immediate deployment score higher than those which require additional development time. This criterion has two measures to identify readiness.
    - *Sequencing/interdependencies* - Projects which do not have dependencies on other projects score more highly as opposed to those which must be part of a sequence and are not ready/beneficial for immediate deployment.
    - *Funding opportunities/availability* - Projects for which there are opportunities for immediate funding score more highly than those with unclear or uncertain funding opportunities.

- **Institutional readiness -** Projects where the Port and its partners are ready for Immediate deployment score more highly than those which require new resources or commitments. This criterion has two measures to identify institutional readiness.
    - *Resource requirements* - Projects with heavy requirements for resources such as staffing, maintenance, and skillsets that are not readily available do not score as highly as those that do not have such requirements.
    - *Local and agency commitment* - Projects with good indicators of existing agency commitment, such as reflection in existing plans, close alignment with policies, etc. score more highly than those without.
- **Mobility –** Projects anticipated to provide congestion relief, reduce queues, or improve travel time reliability (on-time performance).
- **Emissions/Environment -** Those projects which are anticipated to produce benefits in reducing emissions, improving the environment, and reducing noise score more highly than those with minimal benefits in these areas.
- **Safety -** Those projects anticipated to significantly improve safety around the Port score more highly than those with minimal safety improvements.
- **Technology efficacy -** Projects which create technology benefits for the entire Port system score higher than those which function in isolation and/or neither benefit from nor support other projects. There are three criterions for technology efficacy.
    - *Closes a gap or expands an existing system* - One way a project can benefit the Port is through either closing a gap in or expanding an existing system. Projects which do so score higher.
    - *Complexity of the technology* - A project featuring technology that does not integrate smoothly into the existing systems, perhaps because it is still emerging and requires customization, does not score as highly as those which can be easily developed, deployed, and coordinated in the operating environment of the Port.
    - *Data availability* - A project featuring technology which can utilize existing data or provide data that supports other projects/systems scores more highly than a project that requires new or reworked data resources without benefits that extend beyond the project.
- **User needs priority -** Projects that are considered a priority based on the user needs or a functional necessity at the Port score more highly in this criterion.

After several iterations, the criteria have been assigned with equal weighting. As noted earlier, each project receives a score of low, medium-low, medium, medium-high, or high. A project which scored highly in numerous criteria would be of high relative priority.

Several iterations of these tables were generated. The first draft was based on the consultant team evaluation and user input. The final version was driven by CAC and Port consensus. **Table 3** and **Table 4** present the results of this exercise for the Immediate and Future ITST elements, respectively.

Table 3: Prioritization of Immediate ITST Deployments

Project Criteria	Project Readiness	Institutional Readiness	Mobility	Emissions / environmental / noise	Safety	Technology Efficacy	User Needs Priority	Weighted Score	Ranking	2035 B/C
Communications (WiFi)	High	Medium	Medium-Low	Medium-Low	Medium-Low	High	High	3.4	11	
Communications (Fiber)	High	High	Medium-Low	Medium-Low	Medium-Low	High	High	3.7	9	
CCTV upgrade to HD	High	Medium-High	Medium	Medium	Medium	High	High	4.0	6	5.8
Queue Detection	High	Medium-High	Medium-High	Medium-High	High	High	High	4.6	1	4.1
ATMS (includes centrally controlled signal system)	High	High	High	Medium-High	Medium-High	High	Medium	4.4	2	8.8
Adaptive signal systems	Medium-High	Medium	Medium-High	Medium-High	Medium-High	Medium-High	Low	3.4	10	7.4
RFID readers	High	High	Medium-High	Medium	Medium-Low	High	High	4.1	5	7.0
CMS	High	Medium-High	Medium	Medium	Medium	Medium-High	High	3.9	8	5.1
Joint TMC/EOC	High	High	Medium-High	Medium-High	Medium-High	Medium	High	4.3	4	
Supplemental vehicle detection (speed)	Medium-High	Medium-Low	Medium-High	Medium-High	Medium-High	Medium-High	Medium-Low	3.4	11	2.2
C2C Communication (includes interagency collaboration)	Medium	Medium-Low	Medium	Medium	Medium	Medium	Medium	2.9	13	
Advanced train detection system	Medium-High	Medium	Medium-High	High	High	Medium-High	Medium	4.0	7	2.8
WIM technology	Medium	Medium-Low	Medium-Low	Low	Medium-High	Medium	Medium-High	2.7	14	2.1
GoPort App	High	High	High	Medium-High	Medium	Medium-High	High	4.4	2	14.0
Basic smart parking system	Medium	Medium-Low	Medium-Low	Medium	Medium	Medium-Low	Medium-High	2.7	14	1.1

Table 4: Prioritization of Future ITST Deployments

Project Criteria	Project Readiness	Institutional Readiness	Mobility	Emissions / environmental / noise	Safety	Technology Efficacy	User Needs Priority	Weighted Score	Ranking	2035 B/C
Freight signal priority	Medium-Low	Low	High	Medium-High	Medium	Medium-Low	Medium-Low	2. 7	16	[redacted]
Enhanced GoPort App	Medium-Low	Low	High	Medium-High	Medium	Low	Medium	2. 7	16	[redacted]
Dynamic Lane Control	Medium-Low	Low	High	High	Medium-High	Low	Low	2.7	16	[redacted]
DSRC	Low	Low	Medium-High	Medium-High	Medium-High	Low	Low	2.3	21	[redacted]
Enhanced smart parking system	Low	Low	Medium-High	Medium-High	Medium-High	Low	Medium	2.6	20	[redacted]
Enhanced ATMS	Low	Low	High	High	Medium	Medium-Low	Medium-Low	2.6	19	[redacted]
Connected and autonomous vehicles	Low	Low	Medium-High	Medium-High	Medium-High	Low	Low	2.3	21	[redacted]

4.2.2 Implementation of Critical Technologies

The identification of candidate vendor technology solutions hinges on a broad knowledge of the technologies and knowledge of each technology's status and maturity. Vendor technology solutions that are identified as promising will be evaluated for inclusion by considering some of the following criteria:

- Cost of the vendor technology solution
- The vendor technology solution's ability to address or comply with system requirements
- The effort and time that would be necessary to develop and/or incorporate the vendor technology solution
- Trade-offs that may be necessary in order to include the vendor technology solution
- The level of management and maintenance that is needed for the vendor technology solution
- The perceived sustainability of the vendor technology solution (how long is the technology perceived to stay relevant)
- An analysis of the risks and benefits of the vendor technology solution

Additionally, alternatives analysis conducted by the Systems Integration Team can ensure that all vendor solutions developed are compatible with the existing systems of each of the stakeholder agencies while still meeting the needs and goals that are identified by stakeholders.

Appendix A – Application of System Engineering Process

For major projects, comparable to the GoPort Freight ITS project in size and complexity, it is common to have a well-defined Systems Engineering Process. This project will utilize a similar approach that will assure that the intended outcomes are realized.

This section outlines various elements of the plan to apply the Systems Engineering Process to the design, development, implementation, integration, deployment and operation of the GoPort Freight ITS improvements. This section includes discussion on the following:

- General approach to the application of Systems Engineering principles
- Adaptation of Systems Engineering Process to project needs
- Processes for the deployment of Systems Engineering deliverables
- Repository for Systems Engineering documents
- Procurement options
- Integration with Regional ITS Architecture
- Applicable ITS standards
- Systems Engineering application challenges

Planning Approach

The GoPort Freight ITS is a collaborative approach between Alameda CTC, the Port, the City, Caltrans and other agencies to address truck transportation congestion, safety and emission issues that negatively affect the Port maritime and trucking industry. Due to the Ports unique operative characteristics, it is difficult to readily adopt solutions used on other projects.

Upon completion of the information gathering tasks, discussions will be held with system stakeholders to identify solution elements and engineering processes specifically tailored to the GoPort Freight ITS needs. The Systems Engineering team will develop solutions involving people, hardware and software. In addition, this project involves a number of stakeholders, whose experience in operating and managing various transportation systems will be critical to this project delivery. Tasks involved in this effort will provide valuable information on the following:

- How are the engineering activities going to be managed?
- How are the deliverables for the GoPort Freight ITS project going to be delivered?
- How will the GoPort Freight ITS project team provide an operational system to the stakeholders?

System Engineering Needs

The Systems Engineering team will develop the Systems Engineering documents listed in

Table 2 of the systems engineering management plan. As necessary, other members from the stakeholders group will contribute as well. All deliverables will be reviewed and feedback will be provided from assigned team members from Alameda CTC, the Port, the City, Caltrans and other stakeholders.

Key information on various processes used to develop many deliverables such as preliminary needs assessments, PMP, and the processes that will be used to develop the remaining deliverables are outlined in this section. This includes:

- User Needs Assessment (completed and incorporated into the ConOps)
- Project Management Planning
- Risk Management
- Planning of Systems Engineering Process
- Development of ConOps (completed and available from Alameda CTC by request)
- Requirements Analysis
- System Design
- System Integration and Development
- System Verification
- System Validation
- System Operations and Maintenance
- System Performance Evaluation

Each of these areas is discussed further below.

User Needs Assessment

A User Needs Assessment was completed by the Systems Engineering Team, and the results are presented in the GoPort Freight ITS ConOps.

The team gathered stakeholder input to define the User Needs in a number of different ways, including the following:

- Survey – A survey was developed and handed out to hundreds of truck drivers of various trucking companies at the terminal gates. Over 350 responses were received, primarily from motor carriers from the Bay Area and Central Valley. The responses provided information regarding origins and destinations, current system deficiencies, and new technologies and infrastructure improvements that could help the trucking industry.
- Stakeholder Interviews – The stakeholder feedback involved discussions and interviews with various public agencies (the City, Alameda CTC, MTC, Caltrans, etc.), beneficial cargo owners (BCOs), chassis providers, consultants, motor carriers, non-vessel operating common carriers (NVOCCs), and terminal operators, etc. One-on-one phone interviews were conducted with several PETF members as well.

- CAC – A CAC was formed to gather input from public agency project stakeholders. A series of workshops was held to provide a platform for project stakeholders to share ideas, options and strategies that could aid the development and implementation of the GoPort Freight ITS improvements.

Project Management Planning

A PMP is a living document that is subject to revisions as the GoPort Freight ITS project progresses. It identifies the WBS, organizational structure, schedule and other relevant information necessary for effective project management planning. As tasks are completed and project moves to the next phase, the PMP is revised to reflect the current state of the GoPort Freight ITS project with necessary adjustments to the schedule and resources as warranted.

The PMP will be further developed and built upon the project's overall Project Execution Plan and Project Procedures Manual (PEP-PPM) dated October 1, 2017.

Risk Management

It is critical that a Risk Management Plan is developed that defines the overall approach that will be used to identify and minimize potential risks for this project. A Risk Management Plan specifically developed for this project is structured around the following steps:

- Risk Identification – Identification of the risks that may potentially affect the GoPort Freight ITS project and documentation of the characteristics.
- Risk Analysis – Assessment of the potential effects on GoPort Freight ITS project activities of each identified risk based on qualitative and quantitative evaluations, and prioritization of risks based on anticipated effects.
- Response Planning – Development of options and actions to manage identified risks and to reduce threats to GoPort Freight ITS project objectives.
- Risk Monitoring and Control – Processes to implement risk response plans, track risks, monitor residual risks, identify new risks, and evaluate risk process effectiveness.

Planning of Systems Engineering Process

The development and implementation of the GoPort Freight ITS project will closely follow the systems engineering process illustrated in **Figure 1**. The framework for this process was developed based on the guidance provided by Caltrans and FHWA in the *Systems Engineering Guidebook for ITS*. Many regional studies and documents developed by other agencies also contributed to this process. In addition, prior experiences and technical expertise of the various stakeholders and the consulting team played a vital role in developing the elements described in this document.

Development of ConOps

The ConOps was completed by the Systems Engineering Team and identifies the scope, current situation, nature of changes and justification, concepts for the proposed system, operational scenarios, and summary of the impacts.

Requirements Analysis

A Systems Requirements Analysis is initiated once the ConOps Plan is reviewed and approved by the project partners. This analysis will determine the functionality and operational characteristics of system components in quantitative, measurable terms, the improvements in which those components should operate; require human and system interfaces; and constraints that will affect design solutions. Once completed, the requirements will guide the design of the proposed system in later steps of the Systems Engineering Process.

The development of the systems requirement is a two-phase process. The first phase involves decomposing the identified user needs into high-level requirements that define how the proposed system should operate in general. This high-level analysis may include elements such as:

- Input data required for system operations
- Information to display to system users
- Evaluation of performance
- Development of response plans
- Output commands to control devices
- Dissemination of traveler information
- System performance measurement

Development of these high-level requirements will start from the user needs and high-level operational needs identified in the ConOps Plan. From these elements, a preliminary list of high-level requirements will be developed by the GoPort Freight ITS project team based on the stakeholder input, known operational and technological challenges and a preliminary vision of what the system architecture should look like. Once sufficiently developed, these preliminary requirements will then be discussed with the project partners and stakeholders, and necessary refinements will be made. This process allows proper considerations to the resource constraints from partnering agencies that may not have either expertise or staffing levels necessary for this task.

In the second phase, specific subsystem requirements will be developed by conducting a functional analysis of each proposed system component. This task will ensure that there is no conflict between the system and subsystem related requirements. Some of the examples of system elements that may have their requirement defined in details include:

- Interface among system components

- Interface with external systems
- Input data processing module
- Evaluation module
- Decision support system
- Output data processing module
- System access and security
- System configuration

It is expected that the final systems and subsystems requirements will be developed with participation from various stakeholders. To ensure that the high-level requirements are adequately captured, multiple “requirements walkthroughs” may be held, as needed, to enable stakeholders to review and discuss in detail the developed requirements, propose changes to the requirements, and reach concurrence on them. To facilitate the review and development of high-level requirements with stakeholders, different strategies such as small working groups, simulations, scenario analysis and prototyping may be utilized. It is anticipated that not all stakeholders will participate in every task. For example, only a selected group of stakeholders may review and approve the development of requirements defining how the corridor evaluation module will operate. In this case, the team that developed the module will also be fully responsible for the review as well. Although, the development of requirements for interfaces with external systems will require other operating agencies to contribute.

There are several key elements in the development of requirements, such as traceability and clarity. For better traceability, each requirement will be associated with one or more user needs. For clarity, each requirement will be written to make it easily understandable, clear and concise, unambiguous and thorough.

System Design

The intent of the system design is to translate the established system and subsystem requirements into different design elements. This task involves review of the high-level requirements, subsystem requirements, preliminary architectural vision, and various data inputs and outputs for the system and its individual subsystems. Once these elements are defined, detailed data definitions, data flows and data relationships will be developed. In addition, the design team will conduct a functional decomposition of the requirements, defining and assigning specific functions required to address each requirement to its specific subsystem. From this, an initial separation of concerns will be developed for the system and each subsystem. Workflows and high-level use cases or user stories defined by the requirements will be reviewed and translated into system flows, behaviors and states.

These efforts result in identification of drivers that are expected to have the greatest impact on key performance indicators, present specific constraints on the system architecture or present a higher level of risk to the development and deployment of the system. Such issues may include specific system performance needs, limitations of external interfaces, development of acquisition costs, operating and maintenance costs, flexibility required by specific elements or identified risks, feature prioritization, project schedule limitations or security. The GoPort Freight ITS project team will identify and document specific trade-offs necessary for this analysis and the expected impacts on the project cost and risks.

Once the key design drivers are identified, the team will develop a list of design elements, specific strategies, and system-level design patterns to address the system and subsystem requirements and design drivers. From this overall system architecture, including the high-level design elements, data flows, data entity relationship diagrams for each data store, system and subsystem components and their functions, and primary internal and external system interfaces will be developed.

It is anticipated that the system design will involve several project stakeholders during different phases. The decision support system will be primarily developed under the leadership of the Port, while other stakeholders, including the City, Caltrans, Alameda CTC, and consultants will be involved with the design of interfaces. Whether the design of a specific component will be conducted by one entity or another, a significant amount of collaboration is expected to occur among project stakeholders to ensure that design decisions move the GoPort Freight ITS toward a common goal.

A comprehensive requirements traceability matrix that supports the design activities will be developed. This matrix will help assure that the project requirements are met. It will also help produce test plans and test cases in the later stages of the GoPort Freight ITS implementation. Depending on the needs, this matrix may also be used to support the development of requests for proposals and software requirement specifications for work that may be contracted out. In addition to the traceability matrix, trade-off studies, cost/benefit analyses and risk mitigation alternative analyses may also be conducted by the Systems Engineering team to help support deployment decisions.

A number of design reviews are anticipated during the system design process. The design process is iterative in nature. The design reviews will include the following activities, at a minimum:

- Preliminary Overall System Design Review – General review of the defined system architecture and relationship between the various system components prior to initiating the development of specific components.
- Subsystem Design Reviews – This task involves review of the proposed design for each major system component. At least one review will be conducted for each system component at the end of the design stage of the component. If necessary, multiple reviews may be conducted for some components.
- Final System Review – A thorough review of all system design elements will be conducted at the end of the design process. It is anticipated that a significant portion of this review will focus on changes made to the general system design architecture since the initial review. This will allow necessary refinements due to modifications made during the design of specific system components.

Once these reviews are completed, approvals of the proposed component designs will be conducted by relevant stakeholders. Approvals by all stakeholders will be required for system components meant to be used by all, while approval by specific stakeholders will be required for components implementing agency-specific functionalities, such as interfaces with particular traffic monitoring or control systems. During the design process, the Port implementation Lead will monitor project activities to identify possible technical problems with proposed equipment, commercial off-the-shelf hardware or software, and application components being developed. Approval from all affected stakeholders will be requested for any necessary technical trade-offs before making any changes to the system design.

Hardware and Software Development and Unit Tests

Once the final design documents for the components are approved by various stakeholders, the procurement of individual system components will begin. The procurement of some components may be initiated before the design for other components has been completed, if necessary. It is expected that the Port's Implementation lead will oversee the overall progress of the development effort, while the Systems Engineering Team will be fully responsible for the assigned GoPort Freight ITS system components. The Port's oversight will allow the management team to track progress against the established schedule and discuss any unforeseen challenges with the stakeholders as they arise, and address them in a timely manner.

System Integration and Development

The development of the SEMP initiated the planning of how developed system components are to be integrated into a coherent operational system and deployed. The resulting general framework for system integration and deployment is described in **Appendix C – System Integration and Deployment Plan**. This early framework will be refined into a detailed plan during the design process, once it is clear what needs to be built and integrated. This initial system integration and deployment plan will be developed by the Systems Engineer and further refined by the Systems Integrator prior to construction. The GoPort Freight ITS project team will develop, in collaboration with the Port Implementation Lead and other stakeholders, the sequence by which specific system components should be integrated, and identify who will be responsible for the integration of each component. Details of the tests to be conducted to verify that specific components have been successfully integrated will be developed and documented.

System Verification

System verification involves testing of developed systems or subsystems to see if they meet their requirements and whether they conform to the planned design. The planning of verification activities started with the development of this SEMP, with the development of the general framework for system verification defined in **Appendix D – System Verification Plan**. This framework will be refined into a detailed verification plan during the design process, once a clearer picture of what needs to be built and integrated will be available. This initial system verification plan will be developed by the Systems

Engineer and further refined by the Systems Integrator prior to construction. The GoPort Freight ITS project team, working in collaboration with system stakeholders, will define how the testing is to be accomplished to verify each of the major system components and subsystems, as well as the overall system. This means identifying who will conduct various tests, location of the tests, hardware and software to be used, specific test cases to be performed and what documentation of the test results will be developed. Towards the end of the design effort, specific test procedures outlining steps necessary to verify each requirement and design element will be outlined by the Systems Engineer which will be further developed by Systems Integrator. System elements will be verified in an iterative manner. It will begin with the integration activities at the component level and will progress through subsystem development to the verification of the entire system. Once the deployed system is ready for operation, a final verification for system acceptance will be conducted. Where variances are identified, they will be recorded and guide corrective actions to meet the stated requirements. Corrective action, among other possible actions, may include re-design, component reconfiguration or software revisions.

System Validation

System validation involves activities to assess and ensure that the deployed system meets its intended purpose (user needs). It will assess whether the deployed system meets each of the user needs identified in the ConOps Plan. This requires observing system operations under various conditions, potentially conducting controlled system demonstrations, gathering information from system operators on how they use and perceive the system, and collecting information on how disseminated information is accessed by users. **Appendix E – System Validation Plan** of the SEMP outlines a preliminary validation strategy, while detailed procedures to be used to validate the deployed system will be developed by the project partners towards the end of system deployment. Actual system validation will be conducted only after the deployed system has been verified to meet he established requirements and is accepted by the users. Where variances are identified, they will be recorded and guide corrective actions to meet the stated requirements. Corrective action, among other possible actions, may include re-design, component reconfiguration or software revisions.

System Operations and Maintenance

Appendix G – System Operations and Maintenance Plan of SEMP identifies various elements associated with the operational and support environment. As the project team progresses through the system design and implementation, more detailed descriptions of the system operations and maintenance will be developed. An operational manual, maintenance manual, necessary training material and other documentation will be developed as deemed necessary by the project stakeholders.

System Performance Evaluation

Once the system is fully deployed, accepted, and validated, its performance will be evaluated to determine if the intended objectives are met or not. The System Performance Evaluation will be managed by the Alameda CTC PM including the project consultants, with necessary assistance from the stakeholders. The evaluation will involve comparing the roadway, facility and system operations before and after the system has been fully implemented. It will evaluate how the operations have improved and if the users' goals have been achieved. The preliminary evaluation framework is provided in **Appendix F – System Evaluation Plan** of this SEMP. At a later stage of the project, the project development team and key stakeholders will develop specific processes to be utilized for this evaluation.

Document Sharing

The project team is using Bentley ProjectWise V8i (SELECTseries 4) server and user client software for document sharing.

Integration with Regional ITS Architecture

The Bay Area ITS Architecture, updated in 2017, serves as the blueprint for ITS projects in the Bay Area. It is intended to represent the region's existing and future use of information, technologies and automated systems to improve safety and efficiency for travelers and the agencies providing transportation services across all modes in the Bay Area. The ITS Architecture facilitates planning, design, procurement, implementation and testing of ITS systems. Pursuant to 23 CFR 940.9 and 940.11, all Bay Area agencies using federal funds for ITS projects are required to comply with the adopted Bay Area ITS Architecture as well as applicable federal rules and policies.

Specific Port projects included in the Bay Area Architecture include:

- Bay Area *NextGen 511* - Bay Area *511* is a region-wide telephone and Internet traveler information system that integrates regional traveler information across multiple modes and provides it to travelers
- Port Railroad Crossing Management - Equipment used to monitor rail operations within the Port.
- Port Traffic Management Phase 1 - This project will deploy a port-owned TMC, cameras, CMS, signals and detectors. The system will collect traffic conditions and share them with the City TMC and Caltrans District 4 TMC. Cameras and signals will be controlled by the Port TMC. Road network conditions will be shared with CHP and the City emergency management.
- Port Traffic Management Phase 2 - This project will implement CVs to use roadside devices to share information with drivers through vehicle interfaces. This project will also deploy adaptive signal control and systems to inform trucks of when to start their trips to minimize delays and congestion at the port.

Table A-1 shows various market packages defined in the San Francisco Bay Area ITS Architecture and the National ITS Architecture that will be considered for this project.

Table A-1: Relevant ITS Market Packages

User Service	Market Package	Bay Area ITS Architecture	National ITS Architecture
Archived Data (AD) Management	AD1 – Data Mart	✓	✓
	AD2 – ITS Data Warehouse	✓	✓
	AD3 – ITS Virtual Data Warehouse	✓	✓
Advanced Traveler Information System (ATIS)	ATIS01 – Broadcast Traveler Information	✓	✓
	ATIS02 – Interactive Traveler Information	✓	✓
	ATIS03 – Autonomous Route Guidance		✓
	ATIS04 – Dynamic Route Guidance		✓
	ATIS05 – ISP Based Trip Planning and Route Guidance	✓	✓
	ATIS06 – Transportation Operation Data Sharing	✓	✓
	ATIS07 – Travel Services Information and Reservation		✓
	ATIS09 – In-Vehicle Signing	✓	✓
Advanced Transportation Management System (ATMS)	ATMS01 – Network Surveillance	✓	✓
	ATMS02 – Probe Surveillance	✓	✓
	ATMS03 – Traffic Signal Control	✓	✓
	ATMS04 – Traffic Metering	✓	✓
	ATMS06 – Traffic Information Dissemination	✓	✓

User Service	Market Package	Bay Area ITS Architecture	National ITS Architecture
	ATMS07 – Regional Traffic Management	✓	✓
	ATMS08 – Traffic Incident Management System	✓	✓
	ATMS09 – Decision Support and Demand Management	✓	✓
	ATMS10 – Short Range Communication Traveler Information	✓	✓
	ATMS11 – Emissions Monitoring and Management		✓
	ATMS13 – Standard Railroad Grade Crossing	✓	✓
	ATMS14 – Advanced Railroad Grade Crossing		✓
	ATMS15 – Railroad Operations Coordination	✓	✓
	ATMS16 – Parking Facility Management	✓	✓
	ATMS17 – Regional Parking Management	✓	✓
	ATMS23 – Dynamic lane Management and Shoulder Use		
	ATMS24 – Dynamic Roadway Warning		✓
Maintenance and Construction	MC04 – Weather information processing and Distribution	✓	✓
	MC08 – Work Zone Management	✓	✓

User Service	Market Package	Bay Area ITS Architecture	National ITS Architecture
	MC10 – Maintenance and Construction Activity Coordination	✓	✓
	MC12 – Infrastructure Monitoring	✓	✓
Commercial Vehicle Operations	CV01 – Carrier Operations and Fleet Management		✓
	CV02 – Freight Administration	✓	✓
	CV03 – Electronic Clearance		✓
	CV04 – CV Administration Processes		✓
	CV06 – Weigh-In-Motion		✓
	CV07 – Roadside CVO Safety		✓
	CV10 – HAZMAT Management	✓	✓
	CV11 – Roadside HAZMAT Security Detection and Mitigation		✓
Emergency Management	EM02 – Emergency Routing	✓	✓
	EM04 – Roadway Service Patrol	✓	✓
	EM08 – Disaster Response and Recovery	✓	✓
	EM09 – Evacuation and Reentry Management	✓	✓
	EM10 – Disaster Traveler Information	✓	✓
Automated Vehicle System	AVS11 – Automated vehicle Operations	✓	✓

User Service	Market Package	Bay Area ITS Architecture	National ITS Architecture
	AVS12 – Cooperative Vehicle Safety Systems		✓

Applicable ITS Standards

Table A-2 provides a list of standards for consideration when developing system functionalities. The exact set of standards to be considered will depend on the specific functionalities being developed for the proposed system and standards adopted with the Regional ITS Architecture.

Table A-2: Potential Relevant Standards

Development Organization	Standard Title	Code
American Association of State Highway and Transportation Officials (AASHTO) / Institute of Transportation Engineers (ITE) / National Electrical Manufacturers Association (NEMA)	C2C Standards Group	National Transportation Communications for ITS Protocol (NTCIP) 1102-1104, 2104, 2202, 2303-2306, 2501, 2502
	Center-to-Field (C2F) Standards Group	NTCIP 1101-1103, 2101-2104, 2201, 2202, 2301-2303
	Communication between TCM and Legacy Field Devices	NTCIP 1102, 1103, 2101-2103, 2301, 2302, TS2-2013
	Global Object Definition	NTCIP 1201
	Object Definitions for Actuated Traffic Signal Controller Units	NTCIP 1202
	Object Definitions for CMS’s	NTCIP 1203
	Environmental Sensor Station Interface Standard	NTCIP 1204
	Object Definitions for CCTV Camera Control	NTCIP 1205
	Object Definitions for Data Collection and Monitoring Devices	NTCIP 1206
	Object Definitions for Ramp Meter Control Units	NTCIP 1207
	Object Definitions for CCTV Switching	NTCIP 1208
	Data Elimination Definitions for Transportation Sensor Systems	NTCIP 1209
	Object Definitions for Signal System Masters	NTCIP 1210
	Object Definitions for Signal Control and Prioritization	NTCIP 1211
	Object Definitions for Network Camera Operations	NTCIP 1212

Development Organization	Standard Title	Code
	Object Definitions for Electrical and Lighting Management Systems	NTCIP 1213
	Object Definitions for Conflict Monitor Units	NTCIP 1214
	Weather Report Message Set for Environmental Sensor Station (ESS)	NTCIP 1301
	Transit Communications Interface Profiles (TCIP) Incident Management Objects	NTCIP 1402
	TCIP Passenger Information Objects	NTCIP 1403
	TCIP Scheduling/Runcutting Objects	NTCIP 1404
	TCIP Special Representation Objects	NTCIP 1405
	TCIP On-board Objects	NTCIP 1406
	TCIP Control Center Objects	NTCIP 1407
	TCIP Fare Collection Business Area Objects	NTCIP 1408
	Communications Protocols	NTCIP 2001, 2101-2104, 2201-2203
	ITS Standard Specification for Roadside Cabinets	ITS Cabinet v01.02.15
	Advanced Transportation Controller (ATC) Standard	ATC Standard v5.2b
	ATC Model 2070 Standards	ATC 2070 v03.03
	ATC Application Programming Interface (API) Standard	ATC API v02.06a
American Public Transportation Association (APTA)	Transit Communications Interface Profiles	TCIP-S001 3.0.4
American Society for Testing and Materials (ASTM)	DSRC at 915 megahertz (MHz) Standards Group	E2158-01
	5 gigahertz (GHz) Band DSRC Medium Access Control and Physical Layer Specifications	E2213-03
	Standard Guide for Archiving and Retrieving ITS Generated Data	E2259-03
	Standard Practice for Metadata to Support Archived Data Management Systems	E2468-05
	Standard Specifications for Archiving ITS Generated Traffic Monitoring Data	E2665-08
Caltrans	Assembly Bill 3418	AB3418E
IEEE	Standards for Incident Management Message Sets	1512, 1512.1-1512.4
	Standard for Message Sets for Vehicle/Roadside Communications	1455
	Standards for the Interface Between Rail Subsystems and Highway subsystems at a Rail-Highway Intersection	1570

Development Organization	Standard Title	Code
	Wireless Access in Vehicular Environments (WAVE)	802.11p, 1609
Institute of Transportation Engineers (ITE)	Traffic Management Data Dictionary	TMDD ver.3.3
Society of Automotive Engineers (SAE)	On-Board Land Vehicle Mayday Reporting Interface	J 2313
	DSRC Message Set Dictionary	J 2735
	Location Referencing Message specification	J 2266
	Message Set for ATIS	J 2354
	Standard for ATIS Message Sets Delivered over Reduced bandwidth Media	J 2369
	ATIS Family of Standards for Coding of Messages and Phrase Lists	J 2540
American National Standards Institute (ANSI)	Commercial Vehicle Safety and Credentials Information Exchange	TS 285
	Commercial Vehicle Credentials	TS 286

Appendix B – System Configuration Management Plan

A System Configuration Management Plan (SCMP) outlines the process utilized to manage the configuration of the GoPort Freight ITS project. It requires recording and updating information describing the hardware, software and external systems associated with the ITS deployments. The SCMP focuses on evaluating, coordinating, approving and implementing changes in artifacts that are used to construct and maintain systems. In this context, an artifact may be a piece of hardware, software, a procured system or a document regarding a system component.

A SCMP's main objective is to establish and maintain clarity and remove any ambiguity due to existence of different versions of specific system components. During the course of the project, different versions of specific system components may exist due to changes made to these components for a number of reasons. A SCMP helps keep track of changes. In absence of a well-defined and well-enforced Configuration Management process, situations could arise where different team members use different versions of an artifact unintentionally, team members create versions of a specific artifact without proper authority or a wrong version of an artifact is used inadvertently in the development process. The goal of the configuration management plan is to keep a product's performance, functionality and physical attributes consistent with its requirements, design and operational information.

A typical System Configuration Management Plan includes the following:

- Configuration management approach
- Types of BOM used
- Depth of information captured in BOM
- Processes supporting configuration management activities
- Roles and responsibilities of the Configuration Manager

Approach

System Configuration is often combined with Software Configuration Management (SCM). SCM plans typically detail how software will be stored and versioned, and how operating environments will be documented for each of those versions. However, such plans do not normally provide a BOM, i.e. a list of the materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to create and deliver a system.

For the GoPort Freight ITS project, configuration identification will be managed through a BOM. At any given time during the life cycle of the project, the GoPort Freight ITS project's BOM will define the system components as designed, built and operated, depending on the case. This document will be the basis by which changes to any part of the system will be identified, documented and tracked throughout the design development, testing and final delivery phases.

Material and Equipment Used

To clearly describe the proposed system and to manage its configuration, a multi-level BOM will be used. There is a parent-child relationship with hierarchical structure of assemblies and their related parts and components. The top level is the finished product while the second level may have three subsystems each having none to four components. A multi-level BOM, also known as intended BOM, is a list with various items are listed in two or more levels to identify multiple assemblies within a products BOM.

Configuration Management Processes

Configuration management will rely on the following processes to establish and manage the information contained in the BOM.

- Configuration Planning – Definition of how configuration management will be implemented.
- Configuration Identification - Processes for selecting, describing and labeling configuration identifications and recording attributes of a specific configuration in the GoPort Freight ITS' BOM.
- Configuration Control – Processes ensuring that only authorized configuration items are added, removed or changed in the BOM.
- Configuration Monitoring – Monitoring and recording of various changes that were made to a configuration artifact throughout the life cycle of the GoPort freight ITS.
- Configuration Verification – Periodic audits of the BOM and other configuration management date to ensure that the information recorded in the BOM is accurate and factual.

Roles and Responsibilities for Configuration Management

A designated Configuration Manager will first be provided by the System Integration Team[2] during the deployment phase; at the conclusion of the deployment phase, the Port shall take over Configuration Management, and select a staff member for this position.

The Configuration Manager will be fully responsible for all tasks associated with configuration management. Key responsibilities of the Configuration Manager will include the following:

- Provide support to project teams in configuring and base-lining project items
- Prepare configuration documentation and maintain the project's BOM
- Manage configuration management processes
- Maintain quality, integrity and security of the configuration management data
- Periodically review the BOM for accuracy
- Maintain proper version controls of software deliverables

[2] Note the Port will need to approve the System Integration Team staff member proposed for this key position.

- Analyze configuration issues and propose appropriate resolutions

During the deployment phase, the System Integration team Configuration Manager shall work with Port staff to determine how the above steps can be implemented in a way that is consistent with the Port's Asset Management System. Also, any configuration management will mostly pertain to the first few levels of system components, largely due to relatively large nature of the system to be developed.

Appendix C – System Integration and Deployment Plan

This document presents the System Integration and Deployment Plan guideline. The plan shall define the activities necessary to integrate the ITS components to meet functional and performance requirements. The plan will also describe the sequence in which the parts of the system are integrated and deployed. This System Integration Plan is especially important as the GoPort Freight ITS would have multiple different integrations at multiple locations.

The Systems Integration Plan shall be developed by the selected System Integrator. The final System Integration document would be provided to Alameda CTC and the Port in the implementation stage for approval. The integration plan will also identify the roles and responsibilities of each Integrator development group that will be working on the GoPort Freight ITS project.

Specific System Integration Plan guidelines presented in this section are:

1. Approach for System Integration Tasks
2. Integration Frequency
3. Prioritization of Integration Frequencies
4. Deployment Approach
5. Training
6. Roles and Responsibilities

Approach for System Integration Tasks

The System Integration Plan will detail task-based integration processes that will involve various subsystems of the GoPort Freight ITS. System integration will involve the use of a building block approach starting with elements combined into components which are the combined into subsystems and then into a final single system umbrella. At each stage, testing will occur.

The System Integration Plan shall clearly describe the following phases:

- Field Subsystem Integration
- Port Subsystem Integration
- Communications Subsystem Integration
- End-to-End System Integration

The installation and integration of all ITS field devices must be reviewed and all ITS field components must be inspected to ensure that the devices are installed according to the GoPort Freight ITS plans and specifications. The integration plan shall define the integration of each field sub-system.

Performance checks of the installed devices against the detailed component design shall be done. Tests should include functional tests of each component/sub-system, acceptance tests of each sub-system and system tests of the ITS system. Consideration should be given to include a bench testing of each item prior to installation.

Port of Oakland System Integration

The integration plan shall define in detail the integration of each component comprising the GoPort Freight ITS subsystems. This would include, at a minimum:

- Traveler information application
    - Real-time route information and terminal queue information to motor carriers and other stakeholders
    - Real-time audible text message traffic alerts and Port terminal queue-time alerts for truck drivers
    - Real-time dynamic routing for truck drivers – simple audible text message notification to driver
    - Historical route information
    - Static Port truck traveler information
    - Links to other key travel information sites
    - Smart parking
- Drayage optimization application
- Customer service workstations
- Management workstations
- Real time monitoring (CCTV video) workstations
- ATMS
- CMS's server
- Interface to Caltrans and the City TMC

The system integrator shall develop and document tests to verify the following required capabilities in the Integration Plan:

- Diagnostic results
- Information on users traveling into the Port
- Traffic data and roadway video (including camera control signals) from Port to the Caltrans TMC and to the City TMC
- Transmission of CMS messages from Caltrans TMC / City to Port

Communications System integration

The integration plan shall define the full integration of the communications subsystem of GoPort Freight ITS. This would include, at a minimum:

- Roadside communication gear supporting landline and wireless communication links, as applicable
- Common carrier leased line and wireless communication
- Communications between Port TMC and Caltrans TMC and City TMC
- Communications between Port and enforcement equipment
- Communications between Port and CMS's server
- Communications for security system within the Port

The following communication subsystem installation/integration tests performed by the system integrator should be described in the Integration Plan:

- Testing of fiber optic lines
- Wireless communication tester used to access quality of wireless equipment and devices
- Communication of data throughput tests
- Communications error handling tests
- Communications failover and recovery tests demonstrating redundancy and reliability for both wireless and landlines where redundant links are deployed

End-to-End Application Integration

The Integration Plan shall define the integration of each subsystem forming an accurate and reliable end-to-end ITS solutions. The plan shall detail each of the tests that would verify and validate the integration of all subsystems to successfully meet all approved design and contractual requirements.

Integration Frequency

System Integration Frequency would involve one of the following three approaches:

- Single-phase integration – Integration occurs once, when all of the subsystems are completed. This approach is simple and cost-effective but is highly risky, as it is hard to manage integration problems effectively when all components have already been developed. This approach should only be used when other methods are impractical or when the interfaces between systems are simple and unequivocal.
- Incremental – Only small subsystem additions/updates to the system are allowed for each integration cycle. Incremental integration fits well with the agile development methodology but is difficult to apply to larger systems whose subsystems are provided by multiple organizations with different funding, timing, and development methodologies.
- Multi-phase integration – Related subsystems are added/updated to a partially complete system during each integration phase. This approach provides a balance between single phase and incremental integration. It requires more resources than the single-phase approach, but allows identifying issues earlier in the integration process.

For the integration of the GoPort Freight ITS elements, use of a multi-phase integration approach appears to be the best solution. Since some system components may be ready for implementation before others, this approach will allow integrating those components as soon as they become available. The multi-phase approach is also well suited for projects where development phases cannot be determined more than a few months in advance due to considerable flexibility in the timing of subsystem availabilities.

Prioritization of Integration Frequencies

To address this complexity and facilitate the integration of disparate components, the project team's first priority will be to assemble the skeleton of a working system as early in the process as possible. This means focusing on the ability to retrieve data from various existing interfacing systems. Once this is achieved, integration activities could then successively focus on the ability to send data to the various connected systems and the ability to develop traffic and incident management plans based on the collected information. This approach will allow the Systems Integration team to gradually implement and test new functionalities and to identify early operational problems that may affect the development and integration of specific system elements.

The Systems Integration team will opportunistically choose subsystems to be integrated in each integration cycle. While providing continual focus on the core data exchange functionality, new functionalities will be integrated as early as possible so that they can be tested for reliability and be evaluated by their expected users to ensure that they meet their needs.

Deployment Approach

The Deployment Plan shall include, at a minimum, a comprehensive Installation Plan that includes a detailed schedule, a Training Plan and Installation Safety Plan.

The equipment deployment techniques that will be used on the GoPort Freight ITS by the Integrator shall be clearly defined in the Installation Plan and, if accepted by Alameda CTC and other stakeholders, will be applied to all the equipment, subsystem, and software installations. Specific step-by-step sequenced scenarios for the installation of roadside equipment, communications network, and the TMC subsystem shall be provided by the Systems Integrator, combined with a schedule of these various activities. The objective of requesting that the Systems Integrator present the information in this manner is to provide clear and concise details concerning specific installation requirements and techniques.

The following simplified sequence of deployment activities will be performed by the Systems Integrator.

- Pre-Installation activities as follows:
  - Verify civil and conduit work

- Work with Alameda CTC and other stakeholders to finalize the Installation Plan, Installation Schedule, and other deployment documents
- Ensure that all safety procedures are in place
- Secure Caltrans Encroachment Permit or other permits as needed

- Roadside equipment and installation as follows:
  - CCTV equipment
  - CMS's
  - Communications network equipment
  - RFID readers
  - Queue detection equipment
  - Supplemental detection equipment
  - Rail detection and advanced rail grade crossing equipment
  - Signal upgrades
  - WIM equipment
  - Smart parking equipment
  - Other equipment interface as identified in the civil plans

- Port installment as follows:
  - Hardware and Software Installation
  - Workstations
  - ATMS
  - *GoPort* Freight ITS System/App
  - Interface to Caltrans TMC
  - Interface to City's TMC
  - Other equipment interface as identified in the civil plans

- Post-Installation activities as follows:
  - Verify that all the equipment and software are properly installed
  - Verify that each internal subsystem communicate properly to each other
  - Verify that all installed equipment and software operate properly by conducting end-to-end system testing

Training

Training and education include activities needed to ensure that managers, developers, users, operators, and maintenance personnel achieve and maintain the knowledge and skills necessary to operate the proposed ITS system efficiently and effectively. Training is typically undertaken to provide specific skills, such as how to access or operate the proposed ITS system.

During the course of the project, training and education will be performed through the following activities:

- Meetings and presentations
- Formal presentations by experts or users of similar systems
- Hands-on practice sessions
- Videos and online materials

Roles and Responsibilities

In reference to the GoPort Freight ITS Organizational Chart presented in **Figure 3**, the responsibility for the System Integration and Deployment Plan role will be assigned to the System Integration Team. The System Integration and Deployment Plan, along with the Detailed Design (per the guidance defined in **Appendix B – System Configuration Management Plan**) will provide the technical blueprint for the full-scale construction and deployment of the GoPort Freight ITS.

To ensure that the System Integration Team's System Integration and Deployment Plan, and Detailed System Design, are properly developed to ensure project success and reduce program risk, the Systems Engineering Team shall organize two major program reviews as follows:

- Preliminary Design Review - The System Integration Contractor shall present every major design and integration element to a review team consisting of appropriate personnel from Alameda CTC, the Port, and the CAC. Detailed review comments will be collected which will represent a list of actions required for the System Integration Contractor to present.
- Final Design Review - This will consist of the same membership from the Preliminary Design Review. Following the completion by the System Integration Contractor of actions requested by the System Design reviewers, the System Integrations Contractor shall submit the final Detailed Design and System Integration and Deployment Plan documents. Alameda CTC shall then provide a final internal review, and then grant final approval – this will serve as the approval point for the System Integration Contractor to proceed into GoPort Freight ITS construction and deployment.

Appendix D – System Verification Plan

The system acceptance process is critical because this is where the system owner becomes responsible for the continued maintenance and management of the systems, products and processes delivered. Test cases for each of the system requirements will be deployed to detail the test procedure to verify that the overall system requirements are satisfied. The result of the test cases will be documented as Pass or Fail during the final acceptance. Where variances are identified, they will be recorded and guide corrective actions to meet the stated requirements. Corrective action, among other possible actions, may include re-design, component reconfiguration or software revisions.

For the GoPort Freight ITS deployments, verification activities will start with tests conducted on individual system components to verify that each item meets the stated requirements and operates as intended and will end with a test performed on the final, integrated system. This section simply presents the general approach that would be used to conduct verification activities. Detailed verification activities to be conducted will be defined later in the project as the tests to be conducted will depend on the specific characteristics of each system component to be developed. System Verification Plan guidelines addressed in the section are:

- Verification Activities
- Verification Approach
- Requirements Traceability Matrix
- Identification of Test Environment Needs
- System Configuration Tracking
- Verification Activities

Verification tests will be performed for system components specifically developed as part of this project. Exact list of components to be verified will be developed during the drafting of the system requirements. At a minimum following verification activities are expected to be conducted:

- Data communication capabilities between agencies
- Data storage and management
- Information display interfaces
- Processes used to identify and characterize incidents and events
- Input and output data processing
- Processes used to implement recommended control actions
- Interfaces with external systems
- Video and camera control system
- Traffic signal system
- CMS system
- Train detection and rail grade crossing

- *GoPort* truck traveler information system/App
- RFID readers
- Supplemental vehicle detection
- Queue detection
- Advanced traffic management system
- WIM

All system components that will be directly developed by the project team will be subject to verification activities. Existing external systems that will be integrated with GoPort Freight ITS system but not modified will not be subject to verification. Only interfaces developed to communicate with these systems will be verified to ensure appropriate communication and data exchanges. Existing external systems that will be integrated with the GoPort Freight ITS system and modified to enable them to provide specific functionalities will be subject to verification.

Verification Approach

Acceptance testing for GoPort Freight ITS components will consist of a variety of tests ranging from tests at the factory on the proposed equipment through system acceptance testing. The System Integrator shall prepare a detailed Verification Plan for testing all hardware, software and the full integration of the GoPort Freight ITS systems. Acceptance testing will be based on a matrix that is a function of the requirements, specifications, implementation, and the procedures to ensure that all requirements are tested. An overview is provided below with more details in the Detailed Design Requirements Test Plan. The Detailed Design Requirement Test Plan will include further definition of the test environment, input source/output, method of test, and traceability of a test to the requirements.

Verification activities that will be conducted by the System Integrator are presented below:

- Factory Acceptance Tests
- Delivery Tests
- Bench Tests
- Component Tests
- Subsystem Tests
- System Tests

As part of the GoPort Freight ITS, a variety of equipment/material will be required. To ensure this equipment/material is suitable for this project and meets the specifications, it will be necessary that tests be performed at the factory. These tests can range from evaluations on compliance with environmental requirements (i.e., the operating and storage temperature ranges) to the loss per meter in fiber optic cabling.

Delivery Tests

Upon delivery of material to the selected project site, various tests will need to be performed. As a minimum, these tests will be to compare what was ordered with what was delivered and what was specified. Additionally, other tests such as noise loss of fiber optic cable on the reel will be required.

Bench Tests

Following delivery testing, it is imperative that additional testing be performed before placement of the components in the field. This testing will range from simply powering up the component to establishing a mini-network in the shop to demonstrate receipt and transmission of messages as well as compatibility of the various components.

Component Tests

Component testing will involve installations at the Port, at the IT server location, in the field and at remote locations as applicable. Components will need to be connected to the equipment in the cabinet/equipment at their respective locations and tests performed ranging from powering up to receipt/transmission of messages from the connected equipment.

Subsystem Tests

Subsystems to be tested include:

- Port communication system
- *GoPort* Traveler Information system/App
- Traffic monitoring system
- CCTV cameras, vehicle detectors
- CMS
- Traffic signals
- RFID readers
- Supplemental vehicle detection
- Queue detection
- WIM

However, to do subsystem testing, it will be necessary to first have the communications subsystem in place with a connection provided between the various locations. These communication links will need to be individually tested before connection to the transceivers or other communication devices. Recommended testing shall be as per an established Fiber Optic Testing Guideline. With the verification that the communication links are continuous (i.e., able to transmit a signal in both directions), testing of the subsystem can occur. The installed subsystems shall be inspected and tested to validate neat cable placement, cable markings and unit installation in accordance with manufacturer’s installation recommendations. Functional tests shall be conducted for the subsystems to ensure that the subsystems perform the functions as a standalone system.

System Tests

Once the various subsystems have been tested individually, a system acceptance test will need to be performed to ensure that all components (existing and proposed) work together. This will involve end-to-end testing of all linkages. The testing initially consists of testing the functionality of the components by comparing it to the specifications. A traceability matrix is to be developed to aid in this process. Once the functionality of all the subsystems have been successfully tested, the communications subsystem will undergo an acceptance test period. This testing is typically performed over a 30 to 90-day period with rigid requirements that delineate between minor failures and major failures. Throughout the test period any system problems, error failures or malfunctions that are not in compliance with contract requirements shall be categorized based on the level of severity. The typical four levels of severity are:

- Severity 1 – Hardware or software component or process critical to the Port's operation that do not function, and there is the possibility of loss of data.
- Severity 2 – Hardware or software component or process that does not function. There is no risk to loss of data; however, there is possibility of negative impact to Port users.
- Severity 3 – Hardware or software component or process that does not meet the design functionality and/or impedes the operation of the system, but does not affect the collection of data or negatively impacts the Port users.
- Severity 4 – Hardware or software component or process that does not meet the design functionality and/or is cosmetic in nature.

These categories will allow the Systems Integrator team to prioritize the work needed to fix active system issues and to determine when specific verification activities may take place.

All GoPort Freight ITS improvements hardware and software will be carefully tested. Verification that all reported problems have been resolved will be obtained using several methods, including event logs, service call logs, other information gleaned from the maintenance management system, which will be developed and maintained by the Integrator and any other data sources approved by Alameda CTC. Multiple meetings will be scheduled during the test period to ensure that Alameda CTC, the Port and relevant stakeholders are fully aware of all system and equipment failures. The meetings will provide a forum for the stakeholders and Integrator staff to review system/equipment failures and to classify the severity levels.

Requirements Traceability Matrix

To ensure that each of the specified needs put forth in the ConOps is incorporated into the final system, a requirements matrix will be developed that will guide the system verification process. The matrix in **Table D-1** will be used to help trace each specified need that was identified in the ConOps and identify necessary subcomponent requirements that are derived from those needs. It also provides a schedule of completion for each identified requirement.

Table D-1: Sample Requirement Traceability Matrix

System ID	Subsystem ID	Component ID	Requirement Description	Design Spec Section	Test Reference
e.g. 01	*WiFi*	*Access Point 01 (AP#01)*	*Communications Protocol*	*TBD*	*TBD*

This matrix enables the traceability of operational needs (as identified in the ConOps) to system requirements. All requirements are to be written in the form of 'shall' statements. Determination of the requirements is critical for system interface design. This traceability approach is consistent with the System Engineering approach, where only user needs drive the requirements. System requirements are being developed integrally to the development of the PS&E documentation in the form of specifications and functional requirements. This Requirements Traceability Matrix will be used to map verification methods to system requirements.

An initial requirements traceability matrix for the GoPort Freight ITS deployment will be developed by the Systems Engineering development team concurrently with the development of the initial list of requirements. The resulting matrix will then be adjusted as needed as the GoPort Freight ITS progresses through the design of the system and as test protocols are defined and finalized.

Identification of Test Environment Needs

Before the execution of the GoPort Freight ITS's acceptance testing, it is necessary to have a proper support hardware and software setup to facilitate testing. This setup varies from test case to test case and will be identified in detail by the System Integrator. It is expected that the Test Environment will consist of the existing ITS system and the new ITS systems, gateways, communication devices, hardware and other off-the-shelf software developed and/or integrated by the System Integrator.

It is envisioned that simulators will be unnecessary, but the System Integrator will make the final determination. Simulators are typically used to provide the stimulus to the system so that functions can be tested. Simulators are not part of the operational system and are used only to facilitate testing. The operational system in various configurations is proposed to be used to conduct the test.

System Configuration Tracking

Because of the iterative nature of verification activities, it will be important to keep strict configuration control over the system components and documentation. To ensure that the appropriate tests are conducted on the appropriate system elements, the configuration of each component and the test-case version will be verified and noted as part of the verification results.

Appendix E – System Validation Plan

The validation of the system or sub-system will check the functions of the equipment to be sure the originally intended system needs are being met. The system as-built must perform as envisioned during the definitions phases. This validation plan is necessary for complex systems and should identify what needs to be validated, where the validation needs to take place, and when it should happen. The functionality and performance of the system should be validated the user needs and goals are met as they were stated in the ConOps.

This system validation plan lays out the expectations for assessing the developed ITS system for the project. Key elements addressed in this section are:

- Validation Approach
- Development of Validations Procedures
- Validation Test Cases

Validation Approach

The goal of the validation activities will be to demonstrate that the delivered GoPort Freight ITS improvements perform as designed and intended. This would be achieved by assessing the system's functionalities and performance against the user needs, goals, and objectives defined in the ConOps that was collaboratively developed and approved by the stakeholders.

To maximize the chances of successful system validation at the end of the implementation, an in-process validation process will be followed to provide system stakeholders several opportunities to review proposed or developed system elements throughout the system's development and deployment process. Such a process will also help system stakeholders develop an early understanding of the system and any potential issues as they arise.

Implementing an in-process validation will foster an environment in which system stakeholders are provided with multiple opportunities to examine what the proposed system is attempting to achieve and to engage in critical discussions regarding system functionalities. Since validation is to be performed along the way, there should be fewer surprises during the final system validation, as the delivered system will have already been designed to meet the user's expectations. Final system validation will occur after the GoPort Freight ITS has been deployed and accepted by the stakeholders.

Validation activities will be achieved through the following process:

- Review and approval of functional requirements for the proposed ITS projects
- Review and approval of proposed designs for the system components
- Operational reviews of outputs provided by the system components

- Validation of the ITS system by conducting live observation of how the delivered system responds to incidents and events occurring around the Port
- Assessment through interviews and/or surveys of how travelers access and use truck traveler information disseminated by the *GoPort* Freight ITS system/App
- Demonstrations to project stakeholders in controlled environments of how the system would respond to specific situations
- Assessment through interviews and/or surveys of how ITS system operators use the deployed system and how they perceive its effectiveness

Validation Procedures

The specific procedures that will be used to validate the delivered system will be developed by the project management team in collaboration with relevant stakeholders later in the implementation process, when approaching final system delivery. The development of needed procedures may include the identification of supporting data needs, the identification of operational situations to review, the development of observation protocols, the development of survey mechanisms to use to collect information from system operators and system users, and the development of demonstration protocols to examine system operations under hard-to-observe situations. This development will also include the identification of who will be responsible for managing the activities, surveys, interviews, demonstrations, and analyses, as well as the identification of who will be responsible for the execution of specific validation activities.

In addition to defining what is to be done and how, the Systems Integration and Engineering teams will define the processes for handling potential validation failures. This will include defining what information to record to appropriately document the failure; how to determine whether a validation process should be stopped, restarted, or skipped; how to resolve the cause of a failure; and how to determine whether re-validation activities are necessary because of the failure.

Validation Test Cases

Validation test cases are a logical grouping of functions and performance criteria that are to be validated together. Where required, the Systems Integration and Engineering teams will develop specific validation test cases in addition to defining validation procedures. The specific validation test cases to be used during the system validation efforts will be identified and developed by the team members responsible for conducting the validation. These test cases will be developed ahead of the start of the validation effort to allow appropriate review by all the relevant project stakeholders.

At a minimum each identified test case is expected to contain the following information:

- Description name and a reference number
- Complete list of needs and scenarios to be validated by the test case

- Description of the objective of the validation case to aid the reader in understanding the scope of the case
- Any data to be recorded or noted during the validation, such as the expected results of a step or a specific performance measurement
- Statement of the Pass/Fail criteria
- Description of the validation configuration (i.e. of the hardware and software items needed for validation and how they should be connected)
- List of any other important assumptions and constraints necessary for conducting the case

System validation will be conducted using a representative set of validation test cases covering commonly occurring situations. These cases will be developed by the Systems Integration and Engineering teams in consultation with projects stakeholders using the various operational scenarios defined in the Project ConOps. This implies considering at a minimum the following test cases:

- Normal day-to-day operations
- Peak operations
- Major incident within the Port

Appendix F – System Evaluation Plan

After the GoPort Freight ITS systems have been delivered, Alameda CTC and other stakeholders will determine whether the benefits provided by the system justify its usefulness.

A detailed evaluation plan will be produced later in the implementation, when design of the system is complete. This section provides general information on how to conduct an evaluation of the systems deployed. The following elements are discussed in this section:

- Evaluation Objectives
- Evaluation Approach
- Evaluation Metrics
- Data Collection Needs
- Evaluation Roles and Responsibilities

Evaluation Objectives

The objectives behind the evaluation of the proposed GoPort Freight ITS improvements are closely related to the nature of the proposed system deployment. Stakeholders will determine whether the benefits provided by the system are justified.

System evaluation activities will primarily be conducted to quantify the operational benefits provided to system operators and the Port users, as well as the operating costs associated with the deployed solution. More specifically, evaluation activities will be defined and structured to assess the degree to which each of the following expected benefits associated with the general objectives of the project is achieved:

- Improve utilization of the existing infrastructure
- Improve traffic information and management within the Port, its terminal and access routes
- Improve traffic observation, verification and monitoring
- Enhance information sharing during an emergency or incident
- Have the capability of evaluating alternative system management strategies and recommending desired courses of action in response to incidents, events and even daily recurring congestion
- Enhanced TMC at the Port for better traffic control, management and monitoring
- Improve transportation communication with the City and Caltrans
- Reduce traffic congestion, truck idling and emissions
- Provide improved terminal wait time and turn time data information
- Minimize conflicts between transportation modes
- Generate higher Port user satisfaction rates
- Improve travel time reliability
- Improve traffic management during construction projects

Evaluation Approach

Evaluation activities will focus on comparing operations before and after implementation of the proposed GoPort Freight ITS projects, and gathering information on system operating costs. The following are the examples of evaluation activities to be considered:

- Comparison of traffic performance before and after the deployment of the proposed improvements
- Comparison of incident identification, validation and clearance before and after the deployment of proposed improvements
- Interviews with the Port users to collect information on how the deployed system has affected their travel times to the Port wait times at the terminals, operations, reliability, safety, etc.
- Compilation of direct and indirect costs associated with the operations and maintenance of the delivered system

Evaluation Metrics

The ability to quantify how the delivered GoPort Freight ITS produces improvements for the Port and stakeholders will depend on the metrics used. Key performance metrics to be used in support of system evaluation efforts should include but are not limited to:

- Reduction in travel time variability, to measure potential reduction in uncertainties associated with highly variable traffic conditions
- Reduction in terminal wait time and delay, to measure benefits of the implemented Port and traveler information systems
- Reduction in queues and modal conflicts, to measure delay and safety benefits of the implemented strategies

In addition to quantitative performance measure, the system evaluation will also measure how satisfied the users are with the system. This qualitative assessment will be conducted using surveys, interviews, system reviews and direct observation.

Data Collection Needs

Evaluation of the deployed ITS will require at a minimum the collection of data characterizing the following elements before and after implementation of the ITS systems:

- Traffic operations of the existing Port roadway network
- Operations of key freeways used to access the Port
- Operations of the arterial network used to access the Port
- Parking options available at the Port
- Operations of the existing CCTV surveillance

- Operations of the signal systems
- Operations at at-grade rail crossings
- Processes followed by system operators to respond to incidents and manage Port traffic in general

The above evaluation requirements translate into a need to collect the following technical information:

- Port roadway network operations
    - Volume counts at key intersections
    - Average daily traffic (ADT) counts at key locations
    - Speed data
    - Travel time estimates
    - Queue measurements
    - Implemented signal timing plans
- Freeway operations
    - Volume counts on on-ramps, off-ramps and freeway connectors to the Port
    - Implemented ramp metering rates for ramps from the Port
- Arterial operations
    - Volume counts at for key roadways accessing the Port
    - ADT counts at key locations
    - Speed data
    - Travel time estimates
    - Queue measurements
    - Implemented signal timing plans
- Parking availability
    - Number of parking spaces
    - Parking occupancy counts
    - Dwell time
- Port traveler behavior
    - Routes used by the users to access the Port
    - Routes used by the users to detour around freeways and arterial incidents to access the Port
- Port traffic and incident management processes
    - Information describing activities conducted by system operators to manage incidents and traffic in general
- Environmental data
    - Weather information
    - Emissions data
- Event and incidents logs
    - Lane and roadway closure for maintenance or construction
    - Incidents logs

- At-grade crossings
  - Train arrival times
  - Delays at at-grade crossings
- Customer /user satisfaction
- Technology and system effectiveness
  - System statistics
  - Perceptions
  - Failure/maintenance logs
- Information effectiveness
  - Operator
  - User
    - Clarity
    - Relevance
    - Reliability
    - Accuracy
    - Timeliness

The execution of before/after studies will necessitate the collection of data characterizing performance of the Port before and after deployment of the ITS. The following are key principles that will be considered to determine when to initiate the collection of that data:

- Data characterizing the “before” situation will need to be collected before any changes are made to the way traffic is managed at the Port, to ensure that observed differences are primarily attributable to the deployed ITS. This means conducting data collection before the implementation of any procedural changes in how Port operations are managed.
- The collection of data characterizing the “after” situation will be initiated no sooner than six months after the official system launch. This interval should give enough time for system operators to become familiar with how the ITS system operates and to fine-tune system operations. It should provide enough time for the execution of appropriate outreach and marketing campaigns to inform users and stakeholders of what the deployed system can do for them.

While a suggested approach for comparing “before” and “after” system operations is to compare Port operations under similar incidents before and after system implementation, the inherent variability of traffic conditions makes it very difficult to implement this comparative approach. While incidents with relatively similar characteristics are likely to be identified before and after system implementation, changes in traffic demand for the Port and variations in traffic conditions will likely make it very difficult to find situations with matching incidents and traffic conditions. A best approach will therefore simply be to attempt to assess average Port operations under various categories of incidents before and after system implementation.

Multiple “after” evaluations may need to be performed to capture the benefits of the Immediate vs Future improvements.

Evaluation Roles and Responsibilities

In reference to the GoPort Freight ITS Organizational Chart presented in **Figure 3** the responsibility for the evaluation role will be assigned to the Systems Engineering Team. The team shall assign an Evaluation Technical Lead, who will be responsible for defining the evaluation performance metrics, developing the evaluation planning guidance, implementing the evaluation, and developing a final evaluation report.

Appendix G – System Operations and Maintenance Plan

In order to appropriately prepare for operations and maintenance (O&M) of the ITS systems, it is important to analyze and plan for this early in the design process. It is anticipated that this section will be updated as the project concepts and planning are finalized.

Operations and Maintenance Plan

The O&M aspects of the system will be identified within this section of the SEMP. The complete O&M Plan will identify the following:

- Aspects of the system needing O&M
- Personnel (employed or contracted)
    - Initial and on-going personnel training procedures
    - Special skills or other resources required
    - Who will be responsible for the O&M
- Funding and policies supporting ongoing O&M
- Methods to be used to monitor the effectiveness of O&M
    - O&M related data to be collected and how it is to be processed and reported
    - Reporting to be developed for O&M
- Manuals (users, administration and maintenance), configuration records and procedures that are to be used

Aspects of the System Needing O&M

Following the main components of an ITS project, the following is a summary of anticipated O&M needs of the proposed initial deployment:

<u>Communications</u>

The improvements proposed in the ITST Master Plan include expansion of the fiber network and the installation of WiFi access points for “last-mile” connectivity to Port equipment and to allow public access to the Internet. The addition of new fiber should not add a significant amount of supplemental O&M since, in comparison to the existing fiber network, the amount added is a small fraction. Anticipated supplemental maintenance for the additional fiber at the most might include more fiber vaults for periodic inspections. The additional fiber maintenance could be addressed by existing Port contracted electrical and communications services.

The addition of new WiFi access points would add a significant amount of O&M. The Port does have existing WiFi access points as part of its existing enterprise IT network; however, the functionality and demand of a public WiFi system elevates the O&M requirements in correlation to the number of access points and anticipated users. User access issues and vulnerability protection will need to be addressed mostly during normal weekday use of the terminals. However, if night gates are used, coverage will need to be provided during this time.

Facilities

The two Port buildings impacted by the projects proposed in the ITST Master Plan will be the Harbor Facilities Center (HFC) located at 651 Maritime Street and Port Headquarters located at 530 Water Street. The work at the HFC will establish the joint TMC/EOC and will include room renovations that will result in minor changes to the electrical and mechanical systems. The additional configuration of workstations will result in minor changes to the IT network system. No additional maintenance or operations would be considered necessary for these systems.

The addition of the video wall will result in new operational procedures as conducted through daily activities by the room operators. This new wall and the associated video server system will require annual check-up and maintenance that could be addressed through a maintenance contract with a vendor approved contractor.

Both facilities will require new servers and network equipment to address the expansion of the Port Security Management System (PSMS) and addition of ITST field equipment and systems. This equipment will have minimal impact to the existing IT inventory that are part of daily operations and regularly scheduled maintenance.

Field Devices

Several new field devices are proposed in the overall ITST Master Plan; however, only the Immediate deployments will be addressed in the O&M plan at this time. The currently anticipated Immediate deployments will be additional CCTVs, modified traffic signal controllers and video detection cameras, a new RFID system, new CMS's, and new vehicle detectors.

The additional CCTV will expand the current PSMS. These cameras will be added to the current Genetec control system but some will be added to provide supplemental video detection of traffic conditions on the arterials and on rail approaching at-grade crossings. The additional CCTVs will mostly be accessed and controlled on a daily basis by operators at the joint TMC/EOC. These additional CCTVs will add to the current quantity of CCTVs for regularly scheduled maintenance. It is anticipated that this maintenance would be an expansion of the existing Port CCTV maintenance contract.

The modification of the existing traffic signal controllers will add improved access, control and functionality capabilities. The new signal controllers will also add stationary video detection cameras mostly used for signal phase activation but to also allow remote access of vehicle count and movement data. This data can be consumed and analyzed by Port personnel to help identify any traffic issues or challenges. At this time, it's anticipated that O&M will continue to be done by one of the two possible agencies currently controlling the signals – the City or Caltrans. As the ConOps matures and a MOU is established between the Port and the controlling agencies, some operations and maintenance activities might be moved over to the Port.

A new RFID system will be adding new exciters and sensors near the terminal gate entrances and exits for the purposes of measuring turn times through each of the terminals. A new system will be used to provide remote access of the data generated by the RFID devices. It is anticipated that these devices will connect to the fiber network and will be accessed and controlled by a server at HFC or the Water Street location. These new devices will require a regularly scheduled maintenance program that will need to be established – most likely with an approved vendor representative.

Several new permanent CMS's will be placed into the field at select locations along the Port arterials. These signs will be accessed and controlled by operators at the TMC/EOC whereby messages will be entered and displayed reflecting current operations at the Port. Connectivity will be made to the ATMS which can be utilized to provide automated or manual messages based on traffic conditions or incidents at the Port. These new devices will require a regularly scheduled maintenance program that will need to be established.

Video-based (cameras) and radar-based (transmitters and sensors) equipment will be placed into the field at key locations around the Port. This equipment would detect vehicles and/or vehicle speed. These devices will provide traffic data to the ATMS and will not necessarily require any manual operation. These new devices will require a regularly scheduled maintenance program that will need to be established.

GoPort App

This app will consist of a website and mobile app that will be served up either on a local server system installed in a Port building or over a cloud computing network. In the former configuration, a significant amount of operations will be required to address user access issues and vulnerability protection. The equipment will have minimal impact to the existing IT inventory that are part of daily operations and regularly scheduled maintenance. In the cloud configuration, O&M would be handled through a contract mechanism.

Personnel (employed or contracted)

Operations of the elements of the ITST are anticipated to be done through the 24/7 staff currently used for monitoring the PSMS. Supplemental activities would include monitoring of traffic activity on the Port arterials through the ATMS and PSMS. Other traffic related activity would be incident management and message entry for display on the CMS's. It is anticipated that the current staffing of the EOC would be sufficient for the operation of the full joint TMC/EOC.

Maintenance on the other hand will either need to be established through existing contracted service agreements or through employed staff at the Port. It is anticipated that existing IT protocol (using a mix of contracted and staffed personnel) can be used in addressing maintenance needs of the network equipment being used for the ITS. Typically electrical maintenance contractors have the skills, experience and capabilities to carry out the necessary maintenance of all of the field equipment. However, additional specialized skills are needed to address the more technical aspects of signal controllers and video walls.

Operations and Maintenance Funding

The capability of the Port to operate and maintain the system is critical to the successful deployment of an ITS system. If the Port cannot obtain the necessary skill sets in funded positions, the use of contracted maintenance and operations personnel should be considered. Many agencies have successfully deployed systems with a mix of contract and agency personnel. As equipment is procured and established into service, this section of the plan should be updated with information on actual costs in order to better inform the necessary budgets to enable the ITST Master Plan elements. Costs were conveyed in the ITST Master Plan as estimates of O&M.

Collect Operations and Maintenance Information

The types of O&M information that would be collected throughout the operational life of the system should include:

- Record of system inventory including model numbers, serial numbers, manufacturer and vendor information, vendor recommended maintenance, and owner’s manuals
- Record of any disruption of service of the system
- Measures taken to repair the system
- Down time of the system as well as the time to make the repairs

An asset management system can be used to help automate tracking of scheduled maintenance. Short of that automation, reporting should be done at least on an annual basis of all equipment utilized by the ITS.

Operations and Maintenance Documentation

In addition to the information collected on equipment, configuration records and operational procedures need to be written for each of the new equipment added to the ITS. These documents, typically known as Standard Operations Procedures, should be kept in a public place at the joint TMC/EOC.

Appendix H – Glossary

Term	Definition
AASHTO	American Association of State Highway and Transportation Officials
AD	Archived Data
ADT	average daily traffic
Alameda CTC	Alameda County Transportation Commission
ANSI	American National Standards Institute
API	application program interface
app	application
APTA	American Public Transportation Association
ASTM	American Society for Testing and Materials
ATC	Advanced Transportation Controller
ATCMTD	**Advanced Transportation and Congestion Management Technologies Deployment**
ATIS	advanced traveler information system
ATMS	advanced transportation management system
BART	San Francisco Bay Area Rapid Transit
BCO	beneficial cargo owner
BNSF	**BNSF Railway Company (formally known as Burlington Northern–Santa Fe Railroad)**
BOM	Bill of Material
C2C	center-to-center
C2F	center-to-field
CAC	ConOps Advisory Committee
Caltrans	California Department of Transportation
CCTV	closed circuit television
CHP	California Highway Patrol
City	City of Oakland
CMS	changeable message sign (may also be referred as dynamic message signs)
ConOps	Concept of Operations
CPM	critical path method
CPUC	California Public Utilities Commission
CSI	Construction Specifications Institute
CV	Connected Vehicle
DHS	Department of Homeland Security
DSRC	dedicated short-range communication

Term	Definition
EOC	Emergency Operations Center
ESS	environmental sensor station
FHWA	Federal Highway Administration
FRATIS	Freight Advanced Traveler Information System
GHz	gigahertz
GoPort Freight ITS	Global Opportunity at the Port of Oakland Freight Intelligent Transportation System
HD	high definition
HFC	Harbor Facilities Center
IEEE	Institute of Electrical & Electronics Engineers
ILWU	International Longshore and Warehouse Union
INCOSE	International Council on Systems Engineering
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
ITST	Intelligent Transportation System and Technologies
MHz	megahertz
MOU	memorandum of understanding
MTC	Metropolitan Transportation Commission
MTO	Marine Terminal Operator
NEMA	National Electrical Manufacturers Association
NTCIP	National Transportation Communications for ITS Protocol
NVOCC	non-vessel operating common carrier
O&M	operations and maintenance
PDT	Project Development Team
PEP-PPM	Project Execution Plan – Project Procedures Manual
PETF	Port Efficiency Task Force
PM	project manager
PMP	Project Management Plan
Port	Port of Oakland
Project	7th Street Grade Separation and Port Arterial Improvements Project
PS&E	plans, specifications, and estimates
PSMS	Port Security Management System
QA/QC	Quality Assurance / Quality Control
RFID	Radio-Frequency Identification
SAE	Society of Automotive Engineers

Term	Definition
SCM	Software Configuration Management
SCMP	Software Configuration Management Plan
SEMP	System Engineering Management Plan
SOP	standard operating procedure
TCIP	Transit Communications Interface Profiles
TMC	traffic management center
UPRR	Union Pacific Railroad
USDOT	United States Department of Transportation
USCG	U. S. Coast Guard
WAVE	Wireless Access in Vehicular Environments
WBS	Work Breakdown Structure
WiFi	wireless fidelity
WIM	Weigh-In-Motion