THIS PRINT COVERS CALENDAR ITEM NO.: 12

SAN FRANCISCO
MUNICIPAL TRANSPORTATION AGENCY

DIVISION: Transit

BRIEF DESCRIPTION:

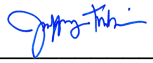
Authorizing the Director of Transportation to execute Contract No. SFMTA-2022-40 FTA with Hitachi Rail GTS USA for design, furnishment, system implementation, support and related services for a Communications-Based Train Control System (CBTC), for a contract term of 9 years of design and procurement with an amount not to exceed $212,093,633, followed by 10 years of support with an amount not to exceed $114,070,833, and two 5-year options to extend the support with an amount not to exceed $237,681,185, for a total contract term of up to 29 years.

SUMMARY:

- The Train Control Upgrade Project (TCUP) is a capital project intended to deliver a modern Communications-Based Train Control (CBTC) system to the SFMTA's Muni Metro light rail system, replacing the loop cable based Automatic Train Control System (ATCS) and expanding train control to the surface portions of the Muni Metro network.
- The CBTC system will leverage significant technological advances to enable the SFMTA to improve reliability, reduce delays, and increase passenger capacity.
- On December 6, 2022, the San Francisco Board of Supervisors passed Ordinance 252-22 waiving the Administrative Code prohibition against issuing solicitations for a contract exceeding ten years and authorizing the use of negotiated procurement procedures for a CBTC contract.
- In March 2023, the SFMTA issued a Request for Proposals (RFP) for a Supplier to provide a CBTC system to replace the ATCS and extend train control to all parts of Muni's rail network.
- The Planning Department has determined that the TCUP is statutorily exempt from the California Environmental Quality Act (CEQA).
- Staff recommends approving the Communications-Based Train Control System (CBTC) and Related Professional Services contract with Hitachi Rail GTS USA.

ENCLOSURES:

1. SFMTAB Resolution
2. Contract Agreement

APPROVALS:		**DATE**
DIRECTOR		October 9, 2024
SECRETARY		October 9, 2024

ASSIGNED SFMTAB CALENDAR DATE: October 15, 2024

PURPOSE

Authorizing the Director of Transportation to execute Contract No. SFMTA-2022-40 FTA with Hitachi Rail GTS USA for design, furnishment, system implementation, support and related services for a Communications-Based Train Control System (CBTC), for a contract term of 9 years of design and procurement with an amount not to exceed $212,093,633, followed by 10 years of support with an amount not to exceed $114,070,833, and two 5-year options to extend the support with an amount not to exceed $237,681,185, for a total contract term of up to 29 years.

STRATEGIC PLAN GOALS AND TRANSIT FIRST POLICY PRINCIPLES

This action will support the following SFMTA Strategic Goals:

Goal 5: Deliver reliable and equitable transportation services.

Goal 8: Deliver quality projects on-time and on-budget.

Goal 9: Fix things before they break and modernize systems and infrastructure.

It will also support the following City Transit-First Policies:

1. To ensure quality of life and economic health in San Francisco, the primary objective of the transportation system must be the safe and efficient movement of people and goods.
2. Public transit, including taxis and vanpools, is an economically and environmentally sound alternative to transportation by individual automobiles. Within San Francisco, travel by public transit, by bicycle and on foot must be an attractive alternative to travel by private automobile.
3. Decisions regarding the use of limited public street and sidewalk space shall encourage the use of public rights of way by pedestrians, bicyclists, and public transit, and shall strive to reduce traffic and improve public health and safety.
4. Transit priority improvements, such as designated transit lanes and streets and improved signalization, shall be made to expedite the movement of public transit vehicles (including taxis and vanpools) and to improve pedestrian safety.

10. The City and County shall encourage innovative solutions to meet public transportation needs wherever possible and where the provision of such service will not adversely affect the service provided by the Municipal Railway.

DESCRIPTION

CBTC Project Background

The SFMTA Muni Metro system currently relies on an Automatic Train Control System (ATCS) to operate trains automatically in the 7-mile Market Street Subway and the new 1.6-mile Central Subway. All but one of Muni's rail lines merge into the dual-track Market Street Subway, which requires that trains move quickly through the tunnel to maintain vehicle flow and headways on the branch lines. While many other light rail systems in the United States still operate using older, fixed-block train control systems, Muni was an early adopter of sophisticated loop-cable based ATCS technology. In service since 1998, the ATCS enables safe, high-frequency service in the core of Muni's light rail network and is the backbone of rail service delivery. However, loop-cable based ATCS technology is now outdated, and the ATCS is at the end of its useful life. In its current condition, train control has caused a high number of delays to Muni's rail service due to daily communication failures, train timeouts and component failures. In February 2020, the Muni Reliability Working Group concluded that upgrading the train control system is the investment in Muni infrastructure that would have the greatest benefit to rail service.

The Train Control Upgrade Project (TCUP) is a capital project intended to deliver a modern Communications-Based Train Control (CBTC) system covering both the surface portions of the Muni Metro network and the subways. The TCUP will deliver a system which continues the excellent safety record of the current system, while also increasing the subway's efficiency and reliability. This technology boost will keep subway congestion to a minimum and reduce delays where trains are held between stations. The proposed contract is the result of SFMTA's open procurement to replace its loop-cable based ATCS with the latest generation radio-based CBTC technology.

With this project, CBTC supervision will be expanded to surface rail lines as well, bringing the entire Muni rail network under a single train control and supervision system. On the surface rail lines, the CBTC system will coordinate train movements with street traffic signals, manage surface junctions and oversee vehicle speed and dwell times to keep trains evenly spaced. This control will provide the SFMTA Transportation Management Center with the tools necessary to manage the entire Muni Metro system and minimize conflicts at junctions and delays at tunnel portals.

During its first phase, the project will introduce CBTC to the street-level Embarcadero and northern Third Street corridors, which serve major civic destinations such as Oracle Park, Chase Center, and UCSF Mission Bay, as a technology demonstration phase. In the second phase, the project will replace the existing ATCS in the Market Street Subway and Central Subway by first overlaying the CBTC on top of the existing system until the new CBTC is ready for commissioning. Over the rest of the nine-year span of the project, CBTC will be extended to the surface branches of the J, K, L, M, N and T lines so that Muni Metro train control is provided by a single CBTC system.

CBTC Project Goals, Contract Structure and Scope of Work

The SFMTA intends to contract with Hitachi Rail GTS USA (Supplier) for a long-term partnership in which the Agency and Hitachi Rail GTS USA will work together to improve the reliability and

performance of the Muni Metro through implementation, operation and maintenance of the vendor's state-of-the-art CBTC system. Hitachi Rail GTS USA is the incumbent supplier of SFMTA's existing SelTrac ATCS system, having purchased the business from Thales GTS USA, formerly Alcatel Canada. SelTrac has an international reputation as a quality CBTC product and has a long track record of safe operation, including with SFMTA. However, SFMTA's version of SelTrac had not been regularly updated since it first went into operation in 1998 and has fallen several generations behind the latest version of the product. Learning from the past, the SFMTA recognizes that its CBTC system should not be a static asset but must be adaptable to changes in transit operations and must be able to incorporate improvements in technology.

This Supplier contract includes design, procurement, testing, commissioning, and long-term support of a state-of-the-art CBTC system. The contract is structured to provide incentives to the Supplier to deliver a reliable CBTC system by tying part of their compensation to its system performance metrics, and the CBTC Supplier will be required to update the CBTC system as train control technology advances.

CBTC systems are proprietary, meaning that the system software, system support, and much of the CBTC equipment can only be obtained from a system vendor under sole source contracts. Generally, the vendor has a significant advantage in negotiating such sole-source support contracts after its system is installed. In the past, City procurement regulations that limit the term of a contract to ten years have effectively prohibited combining procurement and long-term support in a single contract. However, by ordinance passed on December 6, 2022, the San Francisco Board of Supervisors authorized the SFMTA to use negotiated procurement procedures to procure a CBTC system with support services included the authorization to advertise a contract with a 29-year term (to include 20 years of support covering most of the expected 25-year life of the system).

The Supplier contract consists of two parts. The first part of the contract comprises CBTC design, procurement of software and equipment, system testing and certification, and will have a term of nine years. The CBTC will be installed in phases corresponding roughly to each Muni Metro line to give the SFMTA beneficial use of the CBTC before it is fully installed on all rail lines, and to provide opportunities for the new system's performance and stability to be assessed at each installation phase completion milestone. At the end of each phase, the Supplier will test the CBTC to ensure that it meets performance, quality and safety standards and certify each portion of the system for revenue service. The second part of the contract requires the Supplier to provide system support, which includes a supply of spare and replacement parts, troubleshooting and diagnostics, software updates, and related technical services to assist the SFMTA in maintaining and operating the CBTC for most of its expected 25-year life after installation. The system support phase of the contract has a base term of ten years, with two five-year extension options. Both parts of the contract work together to ensure a reliable CBTC system is delivered and kept in a continuous state of good repair.

Like the current ATCS, the CBTC system is fundamental to Muni's rail operations. The design of the CBTC and its performance strongly influences the quality of Muni rail service delivery. As a key objective of this project, SFMTA sought to procure a high-quality CBTC system and secure the vendor's commitment to robust long-term support so that the CBTC-system related delays are kept to

a minimum. To achieve this, SFMTA set up the RFP to evaluate best value, rather than low bid, and required prospective suppliers to competitively commit to performance targets, which were scored as selection criteria alongside the price. Hitachi Rail GTS USA offered the most competitive performance targets in their proposal, which positively contributed to their score. Those submitted performance values are now included in this contract as performance requirements. After the entire system is fully installed, the Supplier's monthly support service fees will be adjusted based on the system's performance relative to the offered performance requirements. This incentivizes the Supplier to design, furnish, test and support a high-quality CBTC system to maximize the compensation it receives.

The SFMTA will contract separately for the installation of train control equipment on the wayside and on the light rail vehicles. The Supplier will provide instructions to these Installers, witness the installation of its equipment, and assist the SFMTA in quality assurance responsibilities with respect to the Installers' work. At the end of installation, after acceptance by SFMTA, the Supplier will inspect and verify the installation of the CBTC equipment, and test and commission the installed system for operations.

The SFMTA also will contract with WSP/PGH Wong Joint Venture for professional consulting services to support the Agency on this project. This Consultant will assist the Agency in managing the relationship between the CBTC Supplier and Installer(s), augment SFMTA project staff with train control system experts, and support system integration and construction management activities. At their August 6, 2024 meeting, the SFMTA Board of Directors passed a resolution authorizing the Director of Transportation to execute Contract SFMTA-2024-20-FTA with WSP/PGH Wong Joint Venture for Consultant support. The San Francisco Board of Supervisors authorized the execution of this Consultant contract at their meeting on September 17, 2024.

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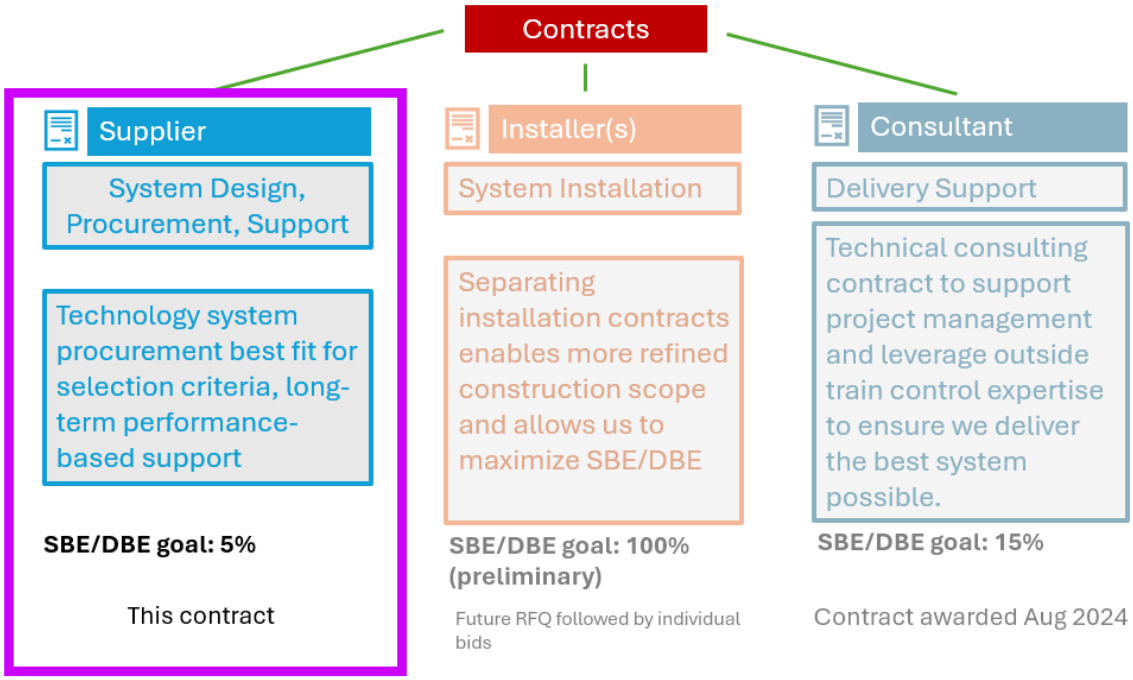
The structure of the separate Supplier, Installer(s), and Consultant contracts is in the image below:



Procurement and CBTC Vendor Selection Process

In 2018, the SFMTA released a Request for Information (RFI) to potential CBTC vendors. The purpose of the RFI was to solicit vendor interest and determine the capabilities and offerings of modern CBTC systems. Eight vendors responded, suggesting a high level of interest. However, three of the vendors did not meet federal contracting requirements, and two mergers of the remaining five vendors collapsed the size of the pool to three potential suppliers. The SFMTA released a follow-up RFI in July 2022 as an industry sounding to determine the viability of SFMTA's anticipated contract, technical, and legal requirements and reassess the state of the industry after COVID. This second RFI informed the final edits to the RFP and associated contract specifications.

The SFMTA then issued a two-stage Request for Proposals (RFP) in March 2023 for the Supplier contract to provide the CBTC system and subsequently hosted a pre-proposal conference with approximately 75 attendees from potential suppliers and subcontractors. In October 2023, SFMTA received two proposals in response to the RFP. In accordance with the negotiated procurement process authorized by the Board of Supervisors for this project, the SFMTA evaluated and scored both proposals using a panel of SFMTA subject matter experts, including an outside panelist from the BART train control project. Based on the evaluation, the SFMTA determined that both proposing firms qualified for the subsequent Request for Best and Final Offers (BAFO).

In preparation for the release of this Request for BAFOs, the SFMTA conducted in-person discussions with both proposers which allowed each of them to understand the weaknesses of their proposal so that they would have the opportunity to improve in the subsequent submission. The

discussions also informed the SFMTA which of its requirements needed to be clarified and/or amended to better align with the capabilities that were available.

The SFMTA issued the Request for BAFOs, with additional clarification and scope refinements informed by the in-person discussions and initial proposal responses, on March 13, 2024. Two responsive proposals were received on June 3, 2024. As a result of the thoughtful information exchange during the in-person discussions and subsequent refinements to the RFP, the SFMTA received much improved offers. They contained more accurate pricing and performance targets, and offered solutions more precisely tailored to the SFMTA's needs. The SFMTA undertook a revised evaluation and scoring process, using the same evaluation panel from the first round. Based on the evaluations of the BAFOs, Hitachi Rail GTS USA was confirmed as the highest-ranking proposer.

Results of RFP Evaluation

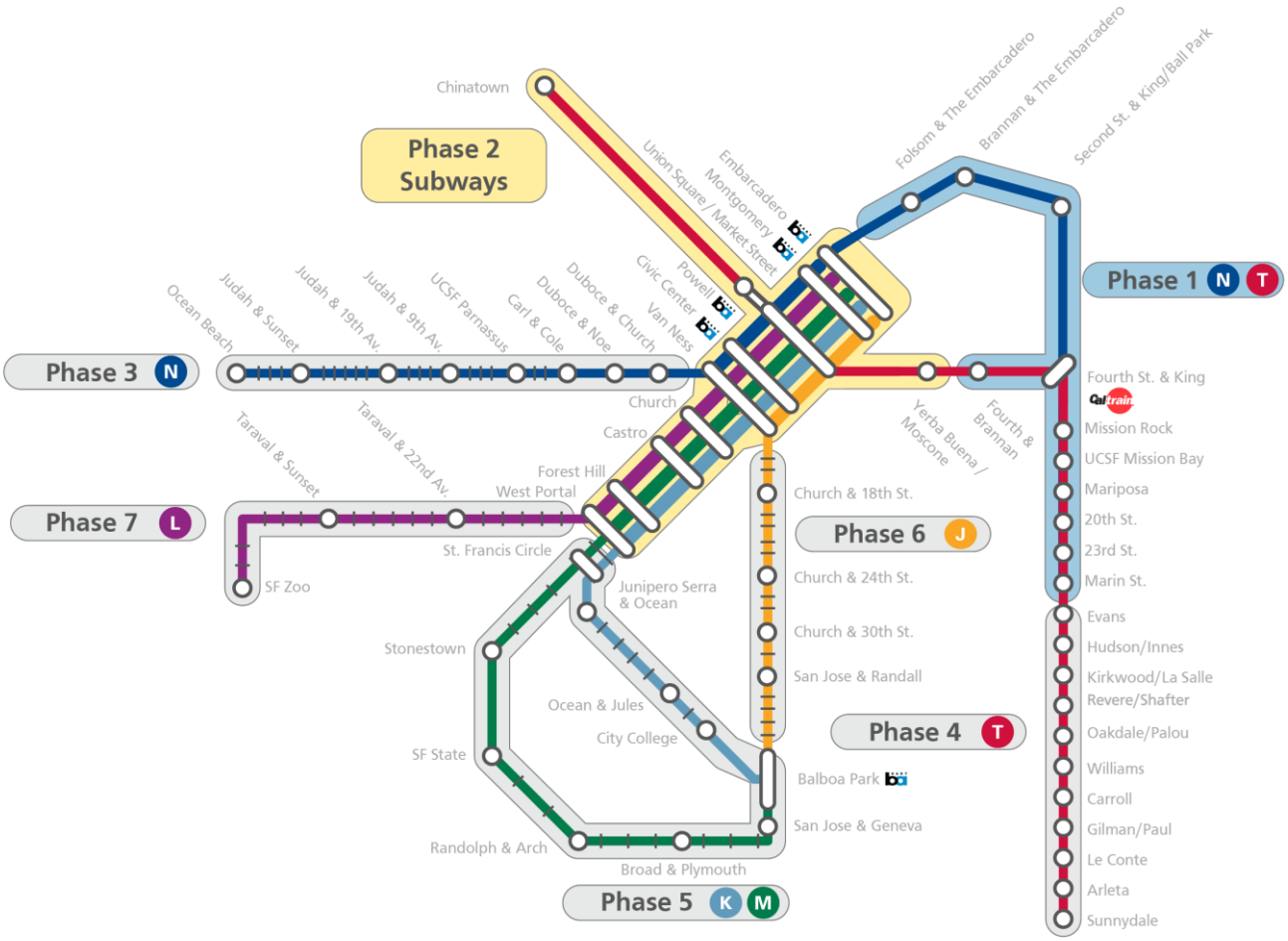
Evaluation Factors	Hitachi Rail GTS USA	Siemens
Total Score (Round 1)	76.09	55.13
Total Score (BAFO)	73.09	58.36

Hitachi Rail GTS USA's proposal displayed a clear understanding of the SFMTA's unique rail operating environment, and proposed a CBTC solution that best met the Agency's objectives. Hitachi Rail GTS USA has extensive worldwide experience delivering successful train control projects and its proposal included the most advanced CBTC technology available in the industry today. Hitachi Rail GTS USA was selected for contract award because it received the highest score with a proposal that best met SFMTA's requirements at the lowest price while committing to the most ambitious performance targets. In the BAFO, Siemens' capital procurement price was almost three times higher than Hitachi's and their ongoing support services price was 1.5 times higher. SFMTA negotiated a contract price with Hitachi Rail GTS USA based on its submitted BAFO price. The negotiated contract is being submitted for approval to the SFMTA Board of Directors herein, and subsequently to the Board of Supervisors as required by Charter section 9.118.

Project Approach

The approach offered by Hitachi Rail GTS USA in its proposal meets the SFMTA's goals and requirements for the project and will result in the best value to the SFMTA. Their SelTrac CBTC system embeds lessons learned from over 25 years of experience working on the Muni Metro system with special emphasis placed on the unique rail system layout with five lines converging into the Market Street subway, and the regular surface/subway transitions at tunnel portals. The SelTrac system offered by Hitachi Rail GTS USA is several generations ahead of SFMTA's current train control technology in the subway and is capable of automatic control, safe train movement, system health monitoring, and seamless transitions between subway and surface operations. Hitachi Rail GTS USA's proposal also includes the replacement of aging surface interlockings which are in need of replacement, integration with surface traffic signals for more reliable surface rail service, the use of transponders for positioning in place of unreliable track circuits, and an innovative means to track heritage and maintenance vehicles. The inclusion of scope addressing all SFMTA surface and

subway signaling issues at once will result in future cost savings because we will be able to avoid multiple replacement projects to cover the same scope, and also reuses much of the existing onboard equipment. The CBTC system will be deployed in phases as shown in the below diagram, starting with an initial segment noted as Phase 1 in blue, before proceeding to replace the ATCS in the subway in Phase 2. Subsequent phases will deploy the CBTC system on the surface as shown.



Support Services Approach

The 20-year support services approach included in the contract reflects SFMTA's commitment to ensure the CBTC system is reliable and kept up to date throughout its expected useful life. The contract requires the Supplier to provide regular software updates and security updates, and to establish an obsolescence management plan to keep the CBTC system current. For the life of the contract, the Supplier will maintain a local inventory of spare parts sufficient to support seamless maintenance and replenish the parts as necessary at no additional cost, which will act as an extended parts warranty for the duration of the support agreement. SFMTA maintenance crews will use the spare parts provided to perform preventative and corrective maintenance. As part of the support scope, Hitachi Rail GTS USA will provide 24-hour technical support, including an embedded System

Support Specialist present in the Transportation Management Center during peak transit hours. This support approach is based on the Supplier's previous 30 years of experience delivering successful train control projects.

Additionally, Hitachi Rail GTS USA has developed training materials instructing SFMTA staff on the operations and maintenance of the CBTC system, so that SFMTA can support the CBTC system. This includes the use of user guides, maintenance manuals, computer-based training modules, training simulators, and other documentation necessary to ensure that training objectives are met. As the system is updated, these training materials will be updated as well.

Stakeholder Engagement

A Muni Reliability Working Group sponsored by the Mayor, the SFMTA Board and members of the Board of Supervisors, and including transportation policy experts, labor union representatives and outside transit agency executives was convened in 2019. The Muni Reliability Working Group reviewed SFMTA's transit operations and the Agency's improvement efforts to reach a shared understanding of where Muni needs support, and recommended priority actions for policymakers. One of the topics considered by the Working Group was improving subway performance, and a key recommendation was to replace the existing train control system with a new CBTC system.

Since the procurement of this system will affect the day-to-day work of SFMTA rail operations and maintenance staff, internal SFMTA staff are the key stakeholders for this project. Starting with the earliest planning activities, the project team has engaged with all SFMTA business units and maintenance shops who currently interact with the existing train control system in the subway and signaling equipment on the surface. Representatives of these units, specifically the Transportation Management Center, Fleet Engineering, Signal Maintenance, Maintenance of Way Engineering, Transit Engineering/SFgo, Transit Services, Transit Program Delivery, Transit Operations, and Technology Solutions and Integration have been identified as Subject Matter Experts (SMEs) for the project. These SMEs have participated in the development of the requirements for this contract, and as such the contract reflects their needs. Several of these SMEs also served on the selection panel for this contract and have applied their expertise to evaluating the proposals.

SFMTA project staff have also engaged in a dialogue with IFPTE Local 21 regarding this project, responding to comments made during the Civil Service Commission approval process. SFMTA will continue to discuss with Local 21 the transition of project team members to permanent positions which will occur towards the tail end of the nine-year procurement phase of this contract.

Muni Metro riders are the other primary stakeholders in this project as they will enjoy the benefits in transit service that a modern CBTC system provides. The SFMTA has conducted briefings with transit advocacy groups and elected officials, informing them of this project and keeping them up to date with project developments. The SFMTA Board has established a TCUP Committee to oversee and advise the project. The TCUP Committee was consulted on the SFMTA's approach to risk management prior to the issuance of the RFP. Members of the TCUP Committee were also briefed on the specifics of this contract following the successful negotiations.

Neighborhood and merchant groups along the Muni Metro rail corridors are also stakeholders because they will benefit from improved rail service to their neighborhoods and businesses, and because they may be impacted by TCUP construction activities. Since the design phase has not begun, the exact construction methodologies and impacts are not yet fully known. The SFMTA plans to outreach to those groups once the construction impacts are better defined, but well in advance of any construction activities. This stakeholder engagement will be reported to the Board when the installation contracts are presented to the Board for approval.

ALTERNATIVES CONSIDERED

No contract. Under this alternative, the SFMTA would have continued to invest resources necessary to maintain the existing ATCS system, keeping the system in a state of good repair for as long as possible. This approach would cost more than a system replacement in the long term. The ATCS is past the end of its useful life and there are already periodic ATCS failures causing minor to moderate disruption to Muni Metro service. Continuing to use the existing system will likely lead to more frequent and severe ATCS failures. These failures may occur unexpectedly, causing sudden closures of the Market Street and Central Subways, causing significant disruptions to subway service. It is possible that in the future the ATCS may completely fail and be unrepairable, at which point rail services would be seriously disrupted for a long period of time, forcing the Agency to replace it under a more urgent timeline and likely at greater cost.

ATCS replacement only (No expansion to the surface). The SFMTA also considered curtailing the deployment of the CBTC to a 1:1 replacement of the ATCS in the subways to reduce the project cost. Not expanding CBTC territory to cover the full Muni Metro rail network reduces the overall benefits of the project and is not cost-effective. A large portion of the project cost can be attributed to system design, software, central equipment and vehicle equipment, which does not change significantly with the size of the territory to be covered. Only a small portion of project cost could be recovered by not expanding train control territory to the surface. Moreover, the surface interlocking equipment is also outdated and in need of replacement. The SFMTA would have to replace the surface interlocking equipment within 5 years anyway to avoid risking service-affecting failures. The surface phases of the TCUP will replace this aging interlocking equipment with the CBTC supplier's more centralized Zone Controllers and Object Controllers. Expanding CBTC to the surface prevents SFMTA from having to perform more interlocking replacement projects in the near future.

FUNDING IMPACT

This contract's scope includes both the procurement and support of the CBTC system and will be funded by both capital funds and the SFMTA operating budget. The procurement portion of this contract is part of the Train Control Upgrade Project and will be funded by the SFMTA capital budget as described in the SFMTA CIP. As portions of the CBTC system are delivered, the SFMTA will phase in payments of support services funded from its operating budget beginning in Fiscal Year 2032.

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The maximum cost of the procurement portion of the contract is $212,093,633, assuming the contract is escalated at the maximum rate allowed under the contract of 6% annually and all procurement options are exercised. The actual escalation rate for labor will be determined by an average of BLS Series CEU3133500003, Series CEU3133600003 and Series CEU6054000003, which are the average hourly earnings for Electrical Equipment, Appliance and Component Manufacturing, Transportation Equipment, and Professional, Scientific, and Technical Services respectively. The actual escalation rate for materials will be determined by an average of the Producer Price Indices for Series PCU334419334419, Series PCU335 and Series PCU336, which are the PPIs for Semiconductor and Other Electronic Component Manufacturing, Electrical Equipment, Appliance and Component Manufacturing, and Transportation Equipment respectively. If these averages are lower than 6% annually, the total project cost will be reduced. Following is a detailed itemization of contract procurement costs and a detailed project budget covering the first nine years of the contract:

Train Control Supplier Contract (Procurement)	**Cost**	
CBTC System design and engineering services	$	43,233,884
Central equipment, simulators, tools, and initial training	$	18,025,207
On-board computers and equipment for LRVs	$	18,127,571
Wayside equipment and testing services for Initial Technology Demonstration	$	23,447,108
Wayside equipment and testing services for Subway Replacement Phase	$	18,341,550
Wayside equipment and testing services for subsequent surface phases	$	37,284,190
Subtotal Train Control Supplier Contract (Procurement)	**$**	**158,459,510**
Option 1: Additional LRV onboard equipment (up to 30 vehicles)	$	5,516,283
Option 2: Heritage Streetcar onboard equipment (up to 50 vehicles)	$	13,923,770
Option 3: Maintenance vehicle onboard equipment (up to 30 vehicles)	$	10,803,013
Option 4: Equipment and design services for motorizing up to 10 additional surface rail junctions	$	10,226,551
Option 5: Backup control center equipment	$	656,305
Option 6: Additional design services to support Heritage Streetcar and/or Maintenance Vehicles	$	12,508,200
Subtotal Train Control Supplier Contract (Procurement + Options)	**$**	**212,093,633**

*All costs escalated to year of expenditure assuming a 6%/yr rate of inflation.

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Other Associated Cost Items	**Cost**
Train control supplier contract (Procurement only)	$ 212 million
Network infrastructure and systems integration	$ 64 million
Installation contracts	$ 99 million
Project management and engineering	$ 102 million
Consultant contract	$ 30 million
Testing, training and operational Support	$ 53 million
Contingency (~25%)	$ 140 million
Total Project Budget	**$ 700 million**

*All costs escalated to year of expenditure.

Capital Funding Plan

The total budget of the Train Control Upgrade Project including all contracts, SFMTA staff cost, contingency, and escalation is approximately $700 million over the nine-year life of the capital project. Work planned for completion during the current Capital Improvement Program cycle (FY25-29) is fully funded. Work planned for completion in future CIP cycles will be funded through future CIP processes. Identified funds include a combination of regional, state, and federal grants. The capital funding plan for the Train Control Upgrade Project is shown below. Some of the proposed sources come with risks. A Transit and Intercity Rail Program (TIRCP) grant is not yet awarded and there is some risk that Prop B General Funds will not be received. This level of risk is consistent with other projects in the Capital Improvement Plan. The project team is aware of this risk and will work with the Capital Budget team to mitigate funding risk and shift funds within the Capital Improvement Plan as necessary. Project funds in hand are sufficient to fund the project through FY25-26. Values outside of the FY25-29 CIP are tentative pending the approval of each subsequent CIP every two years.

This project is not fully funded; the capital funding plan includes a $57 million funding need, which appears outside the SFMTA's CIP planning horizon, starting in FY30. In addition, the funding plan depends heavily on Federal 5337 State of Good Repair formula funds, that if used will risk deferring other projects in the Fixed Guideway capital program which depend on those funds. However, since this is a large, stable project with demonstrable benefits, it is a good candidate for attracting new funding in the form of competitive grants and future bond measures. The project has already been successful in attracting about $31 million of competitive grant funding from one round of the TIRCP. The Agency has submitted state grant applications for additional rounds of funding from the TIRCP, which is included in this funding plan, and for the Solutions for Congested Corridors Program. The SFMTA also plans to include this project in future GO Bond campaigns for transportation capital

improvements. As these new funds are received, they will both close the funding gap and replacing formula funds to reduce the risk to the Fixed Guideway program.

Fund Source	**Fund Type**	**Total ($)**
FTA 5337 State of Good Repair	Federal	$ 375 million
Caltrans SB1 State of Good Repair	State	$ 22 million
Transit and Intercity Rail Program (TIRCP)	State	$ 131 million
General Fund Prop B Transit	Local	$ 30 million
GO Bond (future)	Local	$ 30 million
SFCTA Prop L Transportation Sales Tax	Local	$ 16 million
Revenue Bond*	Local	$ 24 million
Transportation Sustainability Fee (TSF)*	Local	$ 12 million
MTC AB 664 Bridge Toll Funds*	Regional	$ 1 million
Operating Funds*	Local	$ 2 million
Total Committed Funding for this Project		**$ 643 million**
Funding Need		$ 57 million
Total TCUP Budget		**$ 700 million**

*Indicates previously expended capital funds prior to FY25.

Expected capital funding sources for the procurement portion of this contract are shown in the following table:

Fund Source	**Fund Type**	**Total ($)**
FTA 5337 State of Good Repair	Federal	$ 136,358,027
Caltrans SB1 State of Good Repair	State	$ 15,247,645
Transit and Intercity Rail Program (TIRCP)	State	$ 53,000,000
General Fund Prop B Transit	Local	$ 7,487,960
Total Capital Funding for Supplier Contract (Procurement)		**$ 212,093,633**

Future Operating Budget Impact

The contract also includes support services that phase in starting after the new CBTC system has been commissioned in the subways, continuing for 10 years after the procurement portion of the

contract ends. Assuming the contract price is escalated at the maximum rate allowed under the contract of 6% annually, the maximum cost of the baseline support provided under this contract is expected to be no more than $114,070,833. Support services will be covered by the SFMTA operating budget. This amount will be programmed in future SFMTA operating budget cycles between FY32 and FY44.

The contract includes two options to extend the support services for up to an additional ten years each. If exercised, these options would also be funded from SFMTA's operating budget. Assuming the option price is escalated at the maximum rate allowed under the contract of 6% annually, the additional support is expected to cost no more than $237,681,185 and would be programmed in SFMTA operating budget cycles between FY45 and FY54. By signing the contract, the SFMTA is not committing itself to exercise these options, so the Board will have the opportunity to review these costs and the cost-effectiveness of the support plan prior to committing to each 5-year extension of support services.

In the past, the cost of support services has not been presented to the Board up front during the consideration of purchase agreements for technology systems. However, for systems with a long useful life and an ongoing need for support services such as train control systems, the support costs are significant compared to the initial procurement costs. Currently, the SFMTA pays its legacy train control system vendor for limited support services and for spare parts. The support service price for this contract described above includes all spare parts and support services covered by its existing train control support agreements, allowing the SFMTA to offset some of the current operating budget impacts described in this section by retiring those ongoing expenses.

ENVIRONMENTAL REVIEW

The proposed Train Control Upgrade Project is subject to the California Environmental Quality Act (CEQA). CEQA provides a statutory exemption from environmental review—as defined in Title 14 of the California Code of Regulations Section 15275(a) and the California Public Resources Code Sections 21080(b)(10) and 21080(b)(11) – for mass transit projects that institute or increase passenger or commuter service on rail lines already in use, including the modernization of existing stations.

On January 22, 2024, the Planning Department, determined (Case Number 2022-000870ENV) that the Train Control Upgrade Project is statutorily exempt under CEQA pursuant to Title 14 of the California Code of Regulations Section 15275(a) and the California Public Resources Code Sections 21080(b)(10) and 21080(b)(11) (Specified Mass Transit Projects). The Approval Action for that statutory exemption took place when the as-needed consultant services contract for this project was approved by the SFMTA Board on August 6, 2024.

A copy of the CEQA determination is on file with the Secretary to the SFMTA Board of Directors, and may be found in the records of the Planning Department by Case Number at https://sfplanninggis.org/PIM/ or 49 South Van Ness Avenue, Suite 1400 in San Francisco, and is

incorporated herein by reference.

OTHER APPROVALS RECEIVED OR STILL REQUIRED

The contract will require approval from the Board of Supervisors.

The Civil Service Commission approved Personnel Services Contract (PSC) request No. 44370 for this contract on July 15, 2024.

Additionally, the City Attorney's Office has reviewed this report.

RECOMMENDATION

Staff recommends that the SFMTA Board of Directors authorize the Director of Transportation to execute Contract No. SFMTA-2022-40 FTA with Hitachi Rail GTS USA for design, furnishment, system implementation, support and related services for a Communications-Based Train Control System (CBTC), for a contract term of 9 years of design and procurement with an amount not to exceed $212,093,633, followed by 10 years of support with an amount not to exceed $113,922,811, and two 5-year options to extend the support with an amount not to exceed $237,681,185, for a total contract term of up to 29 years.

SAN FRANCISCO
MUNICIPAL TRANSPORTATION AGENCY
BOARD OF DIRECTORS

RESOLUTION No. _____

WHEREAS, The SFMTA operates the Muni Metro light rail system, which includes both shared surface right of way and dedicated subways controlled by an outdated analog loop cable-based Automatic Train Control System (ATCS), which first went into service in 1998, and has reached the end of its useful life; and,

WHEREAS, In February 2020, the Muni Reliability Working Group recommendations included improving the long-term performance of the Muni rail system by replacing the train control system; and,

WHEREAS, On December 6, 2022, the San Francisco Board of Supervisors passed Ordinance 252-22 waiving the Administrative Code prohibition against issuing solicitations for a contract exceeding ten years and authorizing the use of negotiated procurement procedures for a CBTC contract; and,

WHEREAS, In March 2023, the SFMTA issued a Request for Proposals for a Supplier of a Communications-Based Train Control (CBTC) system to replace the ATCS and extend train control territory to surface portions of Muni's rail network, which will leverage significant technological advances in train control that will enable the SFMTA to operate its rail service with greater reliability, reduced delays, and increased passenger capacity; and,

WHEREAS, In March 2024, the SFMTA issued a Request for Best and Final Offers for a Supplier of a Communications-Based Train Control (CBTC) system as part of the approved Negotiated Procurement process; and,

WHEREAS, The requested Supplier contract with Hitachi Rail GTS USA will provide the SFMTA with the design, furnishment, system implementation, warranty, support and related services for a Communications-Based Train Control System; and,

WHEREAS, The SFMTA intends to award a single contract to Hitachi Rail GTS USA for a contract term of 9 years of design and procurement with an amount not to exceed $212,093,633, followed by 10 years of support with an amount not to exceed $114,070,833, and two 5-year options to extend the support with an amount not to exceed $237,681,185, for a total contract term of up to 29 years; and,

WHEREAS, The Civil Service Commission approved Personnel Services Contract (PSC) request No. 44370 in connection with this contract on July 15, 2024; and,

WHEREAS, The proposed Train Control Upgrade Project is subject to the California Environmental Quality Act (CEQA); CEQA provides an exemption from environmental review for mass transit projects that institute or increase passenger or commuter service on rail lines already in use, including the modernization of existing stations, as defined in Title 14 of the California Code of Regulations Section 15275(a) and the California Public Resources Code Sections 21080(b)(10) and 21080(b)(11); and,

WHEREAS, On January 22, 2024, the Planning Department, determined (Case Number 2022-000870ENV) that the Train Control Upgrade Project is statutorily exempt from environmental review under CEQA Title 14 of the California Code of Regulations Section 15275(a) and the California Public Resources Code Sections 21080(b)(10) and 21080(b)(11); and,

WHEREAS, the Approval Action under San Francisco Administrative Code section 31.04(h)(2)(A) occurred when the SFMTA Board of Directors approved the Train Control Upgrade Project Consultant Contract in Resolution No. 240806-098 on August 6, 2024; and,

WHEREAS, A copy of the CEQA determination is on file with the Secretary to the SFMTA Board of Directors, and may be found in the records of the Planning Department by Case Number at https://sfplanninggis.org/pim/or 49 South Van Ness Avenue, Suite 1400 in San Francisco, and is incorporated herein by reference; now, therefore, be it

RESOLVED, That the San Francisco Municipal Transportation Agency Board of Directors authorizes the Director of Transportation to execute, in a form substantially similar to that provided to this body, Contract No. SFMTA-2022-40-FTA for a Communications-Based Train Control System and Related Professional Services contract with Hitachi Rail GTS USA for a contract term of 9 years of design and procurement with an amount not to exceed $212,093,633, followed by 10 years of support with an amount not to exceed $114,070,833, and two 5-year options to extend the support with an amount not to exceed $237,681,185, for a total contract term of up to 29 years; and be it further

RESOLVED, That the San Francisco Municipal Transportation Agency Board of Directors authorizes the Director of Transportation to exercise the options contained in the Contract, to approve inflation-based price escalations under the terms of the Contract, and to approve other Contract Modifications issued under the contract up to the amount of $2,000,000 per Contract Modification; and be it further

RESOLVED, That the San Francisco Municipal Transportation Agency Board of Directors commends this matter to the Board of Supervisors for its approval of Contract No. SFMTA-2022-40-FTA.

I certify that the foregoing resolutions were adopted by the San Francisco Municipal Transportation Agency Board of Directors at its meeting of October 15, 2024.

_____

Secretary to the Board of Directors
San Francisco Municipal Transportation Agency

City and County of San Francisco

Municipal Transportation Agency

One South Van Ness Ave., 7th Floor

San Francisco, California 94103

Agreement between the City and County of San Francisco and

Hitachi Rail GTS USA Inc.

for the Design, Procurement, System Implementation, Support and Related Services for a Communications Based Train Control System

Contract No. SFMTA-2022-40-FTA

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City and County of San Francisco

Municipal Transportation Agency

One South Van Ness Ave., 7th Floor

San Francisco, California 94103

Agreement between the City and County of San Francisco and Hitachi Rail GTS USA Inc. for the Design, Procurement, System Implementation, Support and Related Services for a Communications Based Train Control System

Contract No. SFMTA-2022-40 -FTA

This Agreement for the Design, Procurement, System Implementation, Support, and Related Services for a Communications Based Train Control System ("Agreement" or "Contract") is dated for convenience as _____, 2024 negotiated and to be performed in San Francisco, California, by and between _____ [name of Contractor, with its principal place of business in _____ (Contractor), and the City and County of San Francisco ("City"), a municipal corporation, acting by and through its Municipal Transportation Agency ("SFMTA").

RECITALS

A. The SFMTA wishes to procure a Communications Based Train Control System ("CBTC") that will replace and expand the SFMTA's current train control system, including the Software development, engineering, technical and other services, Equipment and parts, and design, Systems operations, installation oversight, maintenance and related professional and general services necessary to design, procure, provide, implement, test, certify, support and maintain a CBTC.

B. Time is of the essence in the performance of this Agreement, as the SFMTA current train control system has reached the end of its useful life.

C. The Contractor will not perform any work that constitutes a public work. Contractor will not perform installation work on transit and other City vehicles, except as authorized by the SFMTA. The SFMTA will separately contract with third-party Installers to perform Equipment installation on SFMTA's light rail vehicles (LRVs) and wayside and control room Equipment installation.

D. This Agreement was competitively procured as required by San Francisco Administrative Code Chapter 21 through a Request for Proposals (RFP) issued on March 3, 2023, pursuant to which City selected Contractor as having submitted the Proposal that will provide the best value to the SFMTA.

E. The Small Business Enterprise (SBE) subcontracting participation requirement for this Agreement is five percent (5%).

F. Contractor represents and warrants that it is qualified to perform the Services required by City as set forth in this Agreement.

G. The City's Civil Service Commission previously approved Contract numbers 42673 – 21/22 for the System Procurement portion of this Agreement on June 6, /2022, and 41562 – 21/22 for the Support portion of this Agreement on February 7, 2022. Subsequently, the Commission approved the combined Contract number 44370 – 23/24 for this Agreement on July 15, 2024.

H. The Municipal Transportation Agency Board of Directors approved this Agreement by [insert resolution number] on [insert date of Commission or Board action].

I. The San Francisco Board of Supervisors approved this Agreement by [insert resolution number] on [insert date Board action].

J. Now, therefore, in light of the statements in these Recitals, the Parties agree as follows:

GENERAL PROVISIONS

ARTICLE 1 CONTRACT DOCUMENTS

This Agreement is comprised of the following documents ("the Contract Documents"), which together state all obligations, duties, and requirements of the Parties, and the benefits each Party will obtain from performance of this Contract, and constitute the Contract:

1.1. This "General Provisions," document, which establishes the contractual relationship of the Parties and the general terms and conditions of the Agreement.

1.2. The Included Appendices to this Agreement listed in Article 14 of this Agreement.

1.3. Approved Contract Modifications, and approved Change Orders.

ARTICLE 2 DEFINITIONS

The following definitions apply to this Agreement. Where any word or phrase defined below, or a pronoun in place of the word or phrase, is used in any part of this Agreement, it shall have the meaning set forth below. Appendix A (Contract Specifications) and Appendix K (CBTC Software License Agreement) contain additional defined terms, which are incorporated here by reference.

2.1. "Acceptance" or **"Accept"** means the formal written statement to Contractor from the SFMTA acknowledging that all Work that Contractor must provide, (or a specific portion thereof) have been satisfactorily completed in accordance with Contract requirements. See Contract Specifications, Section 8 (Deployment, Migration and Acceptance); see also definition of "Conditional Acceptance," below.

2.2. "Additional Work" means work or services authorized by SFMTA in a Change Order or Contract Modification that is not Work described in the Contract as of the Effective Date and is not Incidental Work.

2.3. "Affiliate" means a legal entity that is directly or indirectly controlled by, or controls the Contractor or is under common control with the Contractor.

2.4. "Agreement" or **"Contract"** means the documents listed in Article 1 (Contract Documents) of the Contract Agreement memorializing the parties' agreement, the bonds or other security, approved Contract Modifications and approved Change Orders, and all applicable City Ordinances and Mandatory City Requirements and other documents that are expressly incorporated into this Agreement. Reference Materials are not Contract Documents.

2.5. "Automatic Train Control System" or **"ATCS"** means the Thales Seltrac system currently installed and in use in the Market Street Subway and Central Subway.

2.6. "Award" means approval of the award of the Contract to Contractor by the SFMTA Board of Directors, the San Francisco Board of Supervisors, and the Mayor, subject to Contractor's providing documents evidencing bonds and insurance coverage as required by this Agreement, and to such other conditions as may be specified in the Request for Proposals, or otherwise required by the City or by law.

2.7. "CCO" means the SFMTA's Contract Compliance Office.

2.8. "Change" means a modification, addition, deletion or other alteration of the Contract Requirements or provisions of the Agreement, or of a Deliverable, as described in a Contract Modification or Change Order, that has already been approved by the SFMTA. See Section 12.5 (Contract Modifications and Change Orders), Appendix A, Contract Specifications, Section 15 (Change Control Procedures), and Appendix E (Contract Changes).

2.9. "Change Order" means a written directive from the SFMTA to the Contractor to effect a change. See Section 12.5.

2.10. "City" means the City and County of San Francisco, a municipal corporation, acting by and through its Municipal Transportation Agency.

2.11. "City Data" or **"Data"** means the data described in Article 13 of this Agreement, which includes, without limitation, all data collected, used, maintained, processed, stored, or generated by or on behalf of the City in connection with this Agreement, as well as City Confidential Information, SSI, infrastructure information, and data provided by a third-party to the City for use under this Agreement.

2.12. "Clarification" means a written communication from the SFMTA responding to a Request for Information explaining a Contract requirement that provides Contractor additional information or context concerning a Contract requirement, but does not modify the Contract requirement at issue. (See Appendix E (Contract Changes).)

2.13. "Closures" means the planned suspension or unplanned interruption of Revenue Service during the usual operating hours and dates listed in SFMTA's Track and Tunnel Access Procedures in Appendix J (SFMTA Policies and Procedures).

2.14. "Commissioning" means the Contractor's certification that a Phase of the CBTC System has passed all required safety tests and may be placed in Revenue Service.

2.15. "Communications Based Train Control System" or **"CBTC System"** or **"CBTC"** generally means a railway signaling system that makes use of telecommunications between the train and track equipment for traffic management and infrastructure control, and specifically refers to the System to be procured under this Agreement.

2.16. "Conditional Acceptance" means the formal written acknowledgement by the SFMTA Director of Transportation or his or her designee that a portion of the Project or Services meets the criteria stated or described in the relevant provisions for that portion of the Project or Services to be accepted. See Section 8 (Deployment, Migration and Acceptance) of the Contract Specifications.

2.17. "Confidential Information" means information, documents, schematics, plans and data that the SFMTA has identified as confidential or otherwise withheld from public access without the express written authority of the SFMTA, which includes, but is not limited to Security Sensitive Information (SSI) and Critical Infrastructure Information (CII), and proprietary information from third parties that is licensed to the SFMTA. See Section 13.1 (Nondisclosure of Private, Proprietary, or Confidential Information).

2.18. "Configure" or **"Configuration"** means the use of native tools in the System to change its behavior or features without modifying the System's Software or Hardware; System performance requirements that can be met through Configuration do not require Customization.

2.19. "Contract Amount" is the value stated in Section 4.5.1 (Calculation of Charges), as that amount may be amended by properly approved Contract Modifications.

2.20. "Contract Documents" means the documents listed in Article 1 (Contract Documents) of the Agreement, which memorialize the Parties' agreement concerning the matters described therein.

2.21. "Contract Modification" means a written amendment to the Contract, executed by the City and Contractor in accordance with the City's Charter and Municipal Codes, effecting changes in the Contract concerning the Term of the Agreement, Contract Amount, or the scope or details of the Work.

2.22. "Contract Rates" means the original prices and rates stated in the Contract at the time the Contract was awarded. See Appendix B (Schedule of Prices and Calculation of Charges).

2.23. "Contract Schedule" means the schedule Contractor submitted with its Proposal, as amended by Contract Modification, which shall be the basis for the Project Schedule. See Appendix D (Contract Schedule).

2.24. "Contract Specifications" means the CBTC System functional, performance, and technical requirements stated in Appendix A (Contract Specifications) of the Agreement.

2.25. "Contract Term" means the period stated in the Contract during which Contractor shall complete the Project, commencing on the date stated in the Notice to Proceed and ending at the conclusion of the Support Term. (See Article 3 (Contract Term).)

2.26. "Contract Time" means times stated in the Contract during which Contractor shall complete Milestones, Phases, and the entire Project, as applicable.

2.27. "Contractor" means Hitachi Rail GTS USA Inc., and as applicable its agents, subcontractors, Affiliates, and suppliers that will perform Work under this Agreement.

2.28. "Controller" means the Controller of the City.

2.29. "Critical Infrastructure Information" means documents, data files, computer files, designs, and other Materials that contain information that may not qualify as Security Sensitive Information, but that the City directs are not to be released to the public or otherwise disclosed as doing so would pose a risk to the security of the City's public transit system, public infrastructure, or to public safety.

2.30. "Customization" means a feature, extension, or modification that requires custom coding and/or some form of special implementation to add function(s) or features to the Software, as more specifically described in the Contract Specifications.

2.31. "Day" (whether or not capitalized) means a calendar day commencing at 12:00 AM and expiring on 11:59 PM, unless otherwise expressly stated. Unless expressly stated otherwise, "Days" shall mean consecutive calendar days.

2.32. "Defect" means a deviation from specified performance requirements of any element(s) of the System, including Software, including but not limited to, a deviation caused by design error, Software Error, omission, or manufacturing error.

2.33. "Delay" is defined in Section 5.18 (Delay, Force Majeure, and Liquidated Damages).

2.34. "Deliverables" means Contractor's work product that are Services provided by Contractor to City under this Agreement, which include without limitation, the work product

described in the Contract Specifications and the Submittals listed in Section 35 (Contract Data Requirements List (CDRL)) of the Contract Specifications.

2.35. "Deployment Phase" means a phase of the Project that results in deploying the fully functional CBTC System over a specifically defined geographic portion of the SFMTA light rail network.

2.36. "Director" means the Director of Transportation of the SFMTA or his or her designee.

2.37. "Disadvantaged Business Enterprise" or **"DBE"** means a for-profit, small business concern owned and controlled by a socially and economically disadvantaged person(s) as defined in 49 Code of Federal Regulations, Section 26.5.

2.38. "Effective Date" means the date the SFMTA notifies Contractor through a Purchase Order and Notice to Proceed that the City's Controller has certified the availability of funds for this Contract as provided in Section 3.1 of Article 3 (Contract Term), and that the Contract has been fully approved and executed by the City.

2.39. "Enhancement" means a modification to the Software to add new features or functions to the Software that is not a general Update or Upgrade to the Contractor's Base System and is requested by the SFMTA under a Contract Modification.

2.40. "Equipment" means the hardware, computers, servers, diagnostic and simulation tools, spare parts, special tools, and all other electronic, mechanical or electrical components to be provided by Contractor that is part of or is necessary to implement the CBTC System under this Agreement.

2.41. "Fix" means repair or replacement of source, object or executable code in the Software to remedy an Error, Defect or Malfunction.

2.42. "Event of Default" is an action or failure to act by Contractor that is a material breach of the Agreement. See Section 9.2.1 (Event of Default).

2.43. "Final Acceptance" means the formal written Acceptance by the SFMTA Director of Transportation or his or her designee that all Contract Deliverables for the Procurement portion of the Contract have been satisfactorily completed and accepted. See Section 8 (Deployment, Migration and Acceptance) of the Contract Specifications.

2.44. "Final Commissioning Date" means the Commissioning date of the Final Deployment Phase.

2.45. "Fiscal Year" means the City and County of San Francisco's fiscal year, from July 1 to June 30. Fiscal years are expressed as two years, i.e., "FY23-24".

2.46. "Force Majeure Event" means an act of God; flood; windstorm; tornado; wars; riot; insurrection; epidemic and other public health emergencies; quarantine restrictions; strikes and lockouts; freight embargoes; acts of a governmental agency exercising regulatory or other police powers; priorities or privileges established for the manufacture, assembly, or allotment of Equipment or Materials by order, decree, or otherwise of the United States or by any department, bureau, commission, committee, agent, or administrator of any legally constituted public authority that delay the progress or completion of the Project, Milestone, or other portion of the Project.

2.47. "FTA" means the Federal Transit Administration.

2.48. "Fully Burdened Labor Rate" means an hourly labor rate that includes wages, benefits, taxes and overhead costs, but does not include profit.

2.49. "Hardware" means Equipment.

2.50. "Heritage Vehicles" is as defined in the Contract Specifications Section 2.4.2, paragraph 1.

2.51. "Incidental Work" means work, expenditure, costs and time that Contractor must expend to perform the Work that is not specifically described in the Agreement as Work, but that is integral and necessary to perform the Work, and customary to be performed by the Contractor.

2.52. "Indemnitee" means any party or entity to which Contractor owes a duty of indemnity of claims and lawsuit as provided in this Agreement. See Section 6.2 (Indemnification).

2.53. "Installer" means a third-party contractor(s) that the SFMTA will engage to install System Equipment on the wayside, in control rooms, and on Vehicles.

2.54. "Issue" means a Defect, Malfunction or Software Failure that the SFMTA has reported to the Contractor in accordance with the procedures described in Appendix I.

2.55. "Issue Report Form" means a form used by SFMTA to report Issues to the Contractor. This form may be electronically submitted.

2.56. "Key Personnel" means Contractor's and Subcontractors' personnel listed in Section 5.8.2, which have specialized expertise and experience necessary for the design and/or implementation of the CBTC and successful completion of the Project.

2.57. "Legacy System(s)" means the SFMTA data and technology systems listed in the Contract Specifications, Section 28.3 (CBTC External Interfaces).

2.58. "Light Rail Vehicle (LRV)" or **"Light Rail Vehicle 4 (LRV4)"** means the light rail vehicles the SFMTA has or will procure from Siemens Mobility, Inc.

2.59. "Loss of Critical Function" is as defined in the Contract Specifications, Section 30.2.1 (Failure Allocation and Categorization).

2.60. "Malfunction" means a deviation between the observed function of the System and the approved documentation of the functionality of the System (e.g., manuals, instructions, CDRLs) furnished by Contractor.

2.61. "Mandatory City Requirements" means those City laws set forth in the San Francisco Municipal Code, including the duly authorized rules, regulations, and guidelines implementing those laws, that impose specific duties and obligations upon Contractor.

2.62. "Materials" means items or supplies necessary for the installation or implementation of the System provided by the Contractor that are not Equipment or Shop Materials.

2.63. "Milestone" means a specific portion of the Work to which the Contract states a completion date and ties compensation to the completion of that Work.

2.64. "Milestone Schedule" means the list of completion dates for the project Milestones contained in Appendix C (Milestone Schedule and Payment) of the Agreement.

2.65. "Muni" means the San Francisco Municipal Railway, a division of the SFMTA.

2.66. "Notice to Proceed" means written notice to the Contractor of the date on which it shall begin performance of the Contract.

2.67. "Option" means the power of the City under the Agreement to direct Contractor to perform additional Work that is identified as an Option, for the price and in accordance with the requirements stated in the Agreement.

2.68. "Owner's Representative" means the SFMTA employee assigned to manage the System for the SFMTA and to direct the Contractor in providing the Support Services. The Project Manager is the Owner's Representative until Final Acceptance.

2.69. "Patch" means temporary repair or replacement of code in the Software to remedy an Error, Defect or Malfunction.

2.70. "Party" and **"Parties"** means the City and Contractor either individually or collectively.

2.71. "Performance Requirement" means the requirements defined in the Contract for System Performance, based on the Performance Targets and Performance Metrics. See Contract Specification, Section 30 (Reliability, Availability and Maintainability).

2.72. "Performance Target" means a quantifiable level of performance or condition, expressed as a value of the measure of performance Contractor shall achieve during the RAM Demonstration and that Contractor shall maintain during the Support Term to qualify for full payment of the Performance Fee. (See Contract Specifications, Section 30.3 (Quantitative RAM Objectives), and Appendix B, section B.2.2.)

2.73. "Phase" means a phase of System Procurement.

2.74. "Precedence" means the higher authority of a Contract Document over all other Contract Documents with lower precedence, used in the construction and interpretation of this Agreement. See Section 12.14 (Order of Precedence).

2.75. "Priority Protocol" means the rules, based on the Priority Category, that specify the time for response or resolution for correcting Errors, Malfunctions and Defects, escalation procedures, and personnel assignment, as specified in the Agreement.

2.76. "Procurement Term" means the initial eight-year period of the Contract Term, ending at System Final Acceptance, during which Contractor shall design, procure, oversee installation, test, certify and implement the CBTC System into Revenue Service. See Article 3 (Contract Term) and Appendix A (Contract Specifications).

2.77. "Project" means the entire endeavor of designing, furnishing, integrating, testing, Commissioning, and supporting the CBTC System, as described and specified in the Agreement.

2.78. "Project Schedule" means the SFMTA-approved schedule prepared by Contractor showing the schedule and deadlines by which Contractor will complete the design, implementation, testing and Commissioning of the CBTC and delivery of related Services, or specified elements or portions of the Project. See Contract Specifications, Section 3 (Project Management).

2.79. "Project Manager" or **"Engineer"** means the SFMTA employee assigned to manage the Project for the SFMTA.

2.80. "Proposal" means the information submitted by Contractor in response to the original RFP 2022-40-FTA as modified by the Best and Final Offer.

2.81. "Proposed Contract Change" (PCC) is a written request from SFMTA to amend the Agreement, as further described in Appendix E (Contract Changes).

2.82. "Proprietary Information" means any confidential or non-public information, which has economic value and is protected with reasonable safeguards to maintain its secrecy owned or disclosed by or on behalf of the Contractor or any of its Affiliates as defined herein. Examples of Proprietary Information include, but are not limited to, trade secrets, technical data, know-how, development plans, business plans and processes, formulas, strategies, improvements, data, network configurations, system architecture, computer programs, designs, drawings, inventions, discoveries, customer lists and financial data belonging to Contractor or Affiliates or customers of Contractor.

2.83. "Purchase Order" means the written order issued by the City to Contractor, authorizing the Effective Date as provided in Section 3.1 (Contract Term).

2.84. "Reduction in Operation Margin" is as defined in the Contract Specifications, Section 30.2.1(Failure Allocation and Categorization).

2.85. "Reference Materials" means those documents, drawings, and other Materials listed in Appendix L (Reference Materials) to this Agreement that the City provides to Contractor for information only; reference Materials are not Contract Documents and are not incorporated into the Agreement. See Section 7.6 (Liability for Reference Materials).

2.86. "Reimbursable Parts" means the parts, special tools or Materials for which the Contractor shall be entitled to reimbursement from the SFMTA due to an out-of-scope replacement. See Contract Specifications, Section 32.4.1 (Provisions of Equipment and Spare Parts), Item 5.

2.87. "Release" means a deployment of the latest release newest version of the Software for use in SFMTA's CBTC System, which supersedes previous versions of the Software.

2.88. "Reliability, Availability, and Maintainability" (RAM) means metrics used to measure the reliability, availability, and maintainability of the System. See Appendix B, section B.2.2, and Contract Specifications, Section 30.3 (Quantitative RAM Objectives).

2.89. "Request for Contract Change" (RCC) is a written request from Contractor to modify the Agreement, as further described in Appendix E (Contract Changes).

2.90. "Resolution Time" means the time between when an Issue is first described/reported in an Issue Report Form and when it no longer occurs. See Appendix I, Section I2.3.

2.91. "Response" means the engagement of Contractor's technical support staff to review and resolve the reported Issue and the initial technical communication between Contractor's technical support staff and SFMTA's staff concerning the reported Issue. See Appendix I, Section I2.3.2.

2.92. "Revenue Service" means the activities by which the SFMTA provides transit services to the public and the state of a transit Vehicle providing transit service for payment of fares.

2.93. "Root Cause Disposition" means Contractor's written explanation of the reasons why an Issue occurred, along with Contractor's recommended plan to resolve the Issue. See Appendix I, Section I2.3.3.

2.94. "San Francisco Municipal Transportation Agency", **"SFMTA"** or **"Agency"** means the City department with jurisdiction over public transit in San Francisco, as provided under Article VIIIA of the City's Charter.

2.95. "Sensitive Security Information" or **"SSI"** is as defined under applicable federal law and federal Department of Transportation security policies, 49 Code of Federal Regulations (CFR) Parts 15 and 1520.

2.96. "Service Affecting Failure" is as defined in Contract Specifications, Section 30.2.1(Failure Allocation and Categorization).

2.97. "Services" means **"Work"**.

2.98. "Severity Level" or **"Priority Category"** means the category assigned to an Issue designating the urgency (priority) informing Contractor's allocation of resources to correct the Issue and the time limits for correction. See Appendix I, Section I2.1 (Severity Levels).

2.99. "Shop Materials" means common Materials that are readily obtainable by Installers in the local (San Francisco Bay Area) market, as determined by the SFMTA and described in Contract Specifications, Section 2 (Summary of Work & Scope Split).

2.100. "Small Business Enterprise" or **"SBE"** means a for-profit, small business concern with a three-year average gross revenue that does not exceed the thresholds set forth by applicable law and either: 1) is certified under any of the following programs: the State of California's Small Business Program with the Department of General Services (State Program), the City and County of San Francisco's LBE Program (City Program), or the California Unified Certification Program (Federal DBE program), or 2) has received written confirmation from CCO that it meets the SFMTA's program eligibility requirements.

2.101. "Software" means all or any part of the specific collection of computer programs and/or machine-readable instructions used to operate or monitor the CBTC provided by Contractor under this Agreement, whether as a stand-alone product, pre-installed on Equipment, or provided as an application (as software as a service) including any Enhancements, Updates or Upgrades to the original Software licensed to the SFMTA under this Agreement. See Appendix K, (CBTC Software License Agreement). Software includes internet or "cloud" based software, including software applications and Software provided as Software as a Service ("SaaS").

2.102. "Software Failure" is as defined in the Contract Specifications Section 1.4 (Definitions).

2.103. "Subcontractor" means any entity that has a contract with the Contractor to perform the Services.

2.104. "Supplier" means any firm or individual under contract to Contractor to provide Equipment, Materials or other goods necessary for Project.

2.105. "Support Fee" means the payment the SFMTA makes to Contractor in exchange for monthly Support Services.

2.106. "Support Services" means Software Updates, Spare parts, remote advice and System problem diagnostics, trouble shooting, as-needed on-site support, remote support, training, and ancillary Services, as described more fully in Contract Specifications, Section 32 (Support Services), and such other services required under the Contract that are necessary to assist the SFMTA maintaining the System during the Contract Term.

2.107. "Support Term" means the portion of the Contract Term after completion of the Procurement Term during which Contractor shall provide Support Services for the CBTC System.

2.108. "System" means the Software, firmware, Equipment, components, subcomponents, subsystems, assemblies, processes, data, and other Services that constitute the CBTC.

2.109. "System Performance" means the actual performance of the System as measured using the Performance Metrics calculated using the methodology set out in the Contract Specifications, Section 30 (Reliability, Availability and Maintainability).

2.110. "Unavoidable Delay" is as defined in Section 5.18.2 (Unavoidable Delay).

2.111. "Unsatisfactory Issue Resolution" means an Issue to which the Contractor did not respond, did not provide a root cause disposition or did not resolve within the "Response and Resolution Time" targets identified in Appendix I. See Section I4.

2.112. "Update" means modifications to the Software to correct Errors, Defects and Malfunctions within the existing functions of the Software, to address security vulnerabilities, and to stay current with the version of the operating system (including operating system updates and patches) installed on the Equipment. Updates are within the scope of prepaid Support Services.

2.113. "Upgrade" means modifications to the Software to add new features or functions to the Software that are offered universally to Contractor's other customers using the same Base

Product as SFMTA's CBTC System, or new versions of the Software developed to facilitate migration of the Equipment to a new operating system. Upgrades are within the scope of prepaid Support Services.

2.114. "Vehicle" means LRVs, Heritage Vehicles, or Maintenance Vehicles that travel on SFMTA trackway and are required to be tracked by the CBTC System.

2.115. "Warranty Period" means the period commencing at Commissioning of each Phase during which the Contractor will provide Warranty Services pursuant to the Contract Documents. See Contract Specifications, Section 13 (Warranty and Spare Parts).

2.116. "Warranty Services" is as defined in Contract Specifications Section 13.2, paragraph 4.

2.117. "Work" means Contractor's obligation to perform and the work product derived from Contractor's performance and provision of design, engineering, manufacturing, testing, Commissioning, labor, supervision, products, Materials, machinery, Equipment, tools, supplies, and facilities described in the Contract and Incidental Work necessary for the implementation and support of the CBTC. The terms Work and Services are synonymous.

2.118. "Workaround" means a change in the procedures followed or end user operation of the Software to avoid an Error, Defect or Malfunction without significantly impairing functionality or degrading the use of the Software or the CBTC.

ARTICLE 3 CONTRACT TERM

3.1. The Contract Term shall commence on the Effective Date of this Agreement and expire 19 years later, on [insert expiration date], unless earlier terminated or extended by Contract Modification(s) as provided in this Agreement. The Contract Term comprises a System Procurement Term followed by a Support Term, which together with all exercised Options shall not exceed a total of 29 years.

3.2. The System Procurement Term commences on the Effective Date of this Agreement and shall continue for a period of not more than 9 years, which includes the warranty coverage at the end of each Phase of the System Procurement.

3.3. The Support Term shall commence at end of the first Warranty Period (for the Pilot and Subway Replacement Phases) of the Procurement Term and continue for a period (base term) of 10 years after Final Acceptance. See Section 2.106 (Support Term) of Article 2 (Definitions). The City has two Options to extend the Support Term for five years each, for a total Support Term not to exceed of 20 years (a portion of which overlaps the Warranty Period for the final Phase of the Procurement Term due to the staggered acceptance of Deployment Phases).

3.4. The phases of the Project within the Contract Term are more specifically described in the Contract Specifications, Section 8 (Deployment, Migration and Acceptance).

ARTICLE 4 FINANCIAL MATTERS

4.1. Certification of Funds; Budget and Fiscal Provisions; Termination in the Event of Non-Appropriation. This Agreement is subject to the budget and fiscal provisions of the City's Charter. Charges will accrue only after prior written authorization certified by the Controller in the form of a Purchase Order, and the amount of City's obligation hereunder shall not at any time exceed the amount certified for the purpose and period stated in such advance authorization. This Agreement will terminate without penalty, liability, or expense of any kind to City at the end of any fiscal year if funds are not appropriated for the next succeeding fiscal year. If funds are appropriated for a portion of the fiscal year, this Agreement will terminate, without penalty, liability, or expense of any kind at the end of the term for which funds are appropriated. City has no obligation to make appropriations for this Agreement in lieu of appropriations for new or other agreements. City budget decisions are subject to the discretion of the Mayor and the

Board of Supervisors. Contractor's assumption of risk of possible non-appropriation is part of the consideration for this Agreement.

THIS SECTION 4.1 CONTROLS AGAINST ANY AND ALL OTHER PROVISIONS OF THIS AGREEMENT.

4.2. Guaranteed Maximum Costs. The City's payment obligation to Contractor shall not at any time exceed the amount certified by City's Controller for the purpose and period stated in such certification. Absent an authorized public emergency, as provided in the City's Charter and Municipal Codes or other applicable laws, no City representative is authorized to offer or promise, nor is the City required to honor, any offered or promised payments to Contractor under this Agreement in excess of the certified maximum amount without the Controller having first certified the additional promised amount and the Parties having modified this Agreement as provided in Section 12.5 (Contract Modifications and Change Orders).

4.3. Certified Funding. The City may receive and authorize funding for this Project in installments. The SFMTA by formal notice will inform Contractor of the value of certified funds, and Contractor shall by formal notice inform the SFMTA when the value of the Services and goods provided has reached 80 percent of the value of the certified funds.

4.4. Amendments to Contract Amount and Term. Contractor shall not be entitled to an increase in the Contract Amount or an extension of the Contract Term unless the Parties memorialize that amendment in a Contract Modification in accordance with Section 12.5 (Contract Modifications and Change Orders).

4.5. Contractor Compensation

4.5.1. Calculation of Charges. The City shall compensate Contractor for Work for the period invoiced in accordance with this Section 4.5 for Work that the Director of Transportation, or his or her designee, in his or her reasonable discretion, concludes have been satisfactorily performed in accordance with Contract requirements. The breakdown of charges associated with this Agreement appears in Appendix B (Schedule of Prices and Calculation of Charges). As provided in Section 4.5.3 (Retention), the City will withhold a portion of payment as retention until the Final Acceptance of the CBTC. In no event shall City be liable for interest or other charges for any late payments.

(a) **Procurement Term.** During the System Procurement Term, SFMTA shall pay Contractor for completed Work as provided in the Milestone Schedule stated in Appendix C (Payment Milestones) in accordance with Contract requirements for that Milestone and the payment requirements stated in Appendix B (Schedule of Prices and Calculation of Charges).

(b) **Support Term.** During the Support Term, Contractor shall provide an invoice to the SFMTA on a monthly basis for Support Services provided (including goods delivered, if any) and the achieved CBTC System RAM performance in the immediately preceding month, according to the schedule set out in Appendix B (Schedule of Prices and Calculation of Charges).

(c) **Not to Exceed Amounts.** Before the end of the System Procurement Term, the amount paid to Contractor under this Agreement shall not exceed two hundred and twenty-four million, four hundred sixty-nine thousand, nine hundred and eighty-nine Dollars ($224,469,989). Until 10 years after Final Acceptance, the amount paid to Contractor under this Agreement shall not exceed three hundred and twenty-six million, one hundred sixty-four thousand, four hundred and sixty-five Dollars ($326,164,465). In no event shall the amount of this Agreement exceed five hundred sixty-three million, eight hundred forty-five thousand, six hundred and fifty-one Dollars ($ 563,845,651), which amount includes all Options (as described in Section 5.2 Exercise of Options), economic price adjustments and compensation described in the Agreement. Notwithstanding the foregoing, the amount of this

Agreement may be changed by Contract Modifications as described in Section 12.5 (Contract Modifications and Change Orders).

4.5.2. City's Payment Obligations. Subject to the provisions of the Contract Documents, progress payments in accordance with Appendix B2, Section B2.1.1 (Payment Procedures) will be made to Contractor for all Work performed in accordance with the Contract. The City's payments to Contractor shall not constitute a waiver by the City of any rights under the Contract and shall not constitute implied acceptance by the City for Work that does not meet Contract requirements. The City's payments to Contractor shall not excuse Contractor from its obligation to replace or reperform non-conforming Work even if the non-conformance of such Work may not have been apparent or detected at the time such payment was made. The City may reject Work that does not conform to the requirements of this Agreement. In such case, Contractor must replace or reperform non-conforming Work without delay and at no cost to the City.

4.5.3. Retention

(a) The SFMTA will hold five percent (5%) in retention ("Retained Funds") from each Milestone payment it makes to Contractor for Work satisfactorily performed. Retained Funds are held for the benefits and protection of the SFMTA.

(b) The City shall release fifty percent (50%) of Retained Funds upon the following conditions: (a) Conditional Acceptance of the Subway Replacement Phase; and (b) the Contract is free of offsets by the City for liquidated damages, claims, and defective Work, and is free of forfeitures and other charges.

(c) The City shall release all remaining Retained Funds only upon the following conditions: (a) the SFMTA has issued Final Acceptance of the CBTC; and (b) the Contract is free of offsets by the City for liquidated damages, claims, and defective Work, and is free of forfeitures and other charges.

(d) The Contractor may apply for early release of retention for Work performed by any subcontractor whose portion of the Work is complete and has been conditionally accepted by the SFMTA. Contractor shall make such application in writing and shall certify the following:

4.5.3.d.1 That the Work by the subcontractor is complete and satisfactory in accordance with the Contract Documents;

4.5.3.d.2 The total amount paid to the subcontractor by Contractor as of the date of the written request; and

4.5.3.d.3 The amount of Retained Funds associated with the Work performed by the subcontractor.

(e) Contractor acknowledges and agrees that the release of Retained Funds under this subparagraph shall not reduce the responsibilities or liabilities of the Contractor or its surety(ies) under the Contract or applicable law.

(f) At the request and expense of Contractor, the Retained Funds may be placed in escrow in an interest-bearing account approved by the City's Controller. Upon Contractor's request, the City will authorize the escrow agent to release to Contractor the accrued interest from the Retained Funds, no less often than quarterly.

(g) The City shall have the right to use and apply Retained Funds, in whole or in part, to reimburse the City for all liquidated damages due or to become due to the City, complete Work that Contractor is unwilling or unable to complete, and to satisfy any claim or other obligation of the Contractor under the Contract. Any remaining balance of such retained funds shall be paid to Contractor only after discharge in full of all liability incurred by Contractor. If the Retained Funds are not sufficient to discharge all such liabilities of Contractor,

Contractor and its sureties shall remain liable to the City until all such liabilities are satisfied in full. Should the Retained Funds be insufficient to cover such damages, Contractor shall pay forthwith the remainder to the City.

4.5.4. Withhold Payments. If Contractor fails to perform the Work in accordance with Contractor's obligations under this Agreement, the City may withhold payment for any element of the Work in dispute until that element of the Work is properly performed, and Contractor shall not stop, suspend or slow its performance of the Work as a result of City's withholding of payments as provided herein.

4.5.5. Invoice Format. Invoices submitted by Contractor under this Agreement must be in a form acceptable to the City's Controller and the SFMTA. City will make payment as specified in Section 4.5.9 (Contractor Payment), or in such alternate manner as the Parties have agreed upon in writing. All invoices must include the following:

a. A unique invoice number;
b. A specific invoice date;
c. PeopleSoft Contract and Purchase Order ID numbers;
d. PeopleSoft Supplier Name and ID;
e. Relevant Milestones
f. Complete description of Work invoiced
g. Quantity of items;
h. Description and quantity of invoiced items;
i. Unit prices of invoiced items;
j. Sales/use tax;
k. Total invoice amount;
l. Retention calculation;
m. Monthly progress report as required by Contract Specifications, Section 3.6.1 (Monthly Progress Report).
n. Monthly performance report compared to performance standards stated in Contract Specifications, Section 30.3 (Quantitative RAM Objectives) (when applicable)
o. Supporting documentation to demonstrate achievement of Relevant Milestone

Invoices that do not include all required information or contain inaccurate information will not be processed for payment.

4.5.6. Payment Terms

(a) Unless the SFMTA notifies Contractor that a dispute exists, the City will make a good faith effort to issue payment within 30 Days from the date of receipt of the invoice. Payment is deemed to be made on the date on which City has posted the electronic payment to Contractor. In the event that City does not make payment within a reasonable amount of time after such thirty (30) day period or is unable to make payments after such thirty (30) day period, then Contractor will have the right to suspend the Work until such payment arrangements are mutually agreed upon by the Parties.

(b) No additional charge or interest shall accrue against City in the event City does not make payment within any time specified by the Contract.

4.5.7. Progress Payment Form. The SFMTA will not authorize payment of an invoice submitted by Contractor prior to Contractor's submission of the SFMTA Progress Payment Form (SFMTA Form No. 6). If Contractor does not submit SFMTA Form No. 6 with its invoice, the SFMTA will notify the Contractor of the omission. If Contractor's failure to

provide SFMTA Form No. 6 is not explained to the SFMTA's satisfaction, full or partial payment may be withheld until Contractor submits the completed SFMTA Form No. 6.

4.5.8. SBE Payment and Utilization Tracking System. Contractor shall pay SBE/DBE subcontractors within three business days of the SFMTA's payment of an invoice. Within 10 business days of the SFMTA's payment of an invoice, Contractor shall confirm to the SFMTA that all subcontractors have been paid via the B2Gnow System (https://sfmta.diversitycompliance.com/). Failure to submit all required payment information into B2Gnow may result in full or partial withholding of future progress payment requests until Contractor submits the required information.

4.5.9. Contractor Payment

(a) The City utilizes the Paymode-X® service offered by Bank of America Merrill Lynch to pay City contractors. Contractor must sign up to receive electronic payments to be paid under this Agreement. To sign up for electronic payments, visit http://portal.paymode.com/citycountyofsanfrancisco.

(b) The City may require Contractor to submit invoices directly in the City's financial and procurement System (PeopleSoft) via eSettlement. Refer to https://sfcitypartner.sfgov.org/pages/training.aspx for more information on eSettlement. For access to PeopleSoft eSettlement, submit a request through sfemployeeportalsupport@sfgov.org.

4.5.10. Grant-Funded Contracts

(a) **Disallowance.** If Contractor requests or receives payment from City for Services, reimbursement for which is later disallowed by the State of California or United States Government, Contractor shall promptly refund the disallowed amount to City upon City's request. In its discretion, City may offset the amount disallowed from any payment due or to become due to Contractor under this Agreement or any other Agreement between Contractor and City.

(b) **Grant Terms.** The funding for this Agreement is provided to the SFMTA in full or in part by a federal or State grants. As part of the terms of receiving the funds, the SFMTA must incorporate some of the terms of that grant agreement into this Agreement ("Grant Terms"). The incorporated Grant Terms are stated in Appendix G (Federal Contract Requirements). To the extent that any Grant Term is inconsistent with any other provisions of this Agreement such that Contractor is unable to comply with both the Grant Terms and the other provision(s), the Grant Terms shall apply.

(c) **Subcontractors.** As required by the Grant Terms, Contractor shall insert applicable provisions into each lower-tier subcontract. Contractor is responsible for compliance with the Grant Terms by its subcontractors, Affiliates, lower-tier subcontractors, or service providers.

4.6. Audit and Inspection of Records. Contractor agrees to maintain and make available to the City, during regular business hours and subject to the Contractor's security protocols, accurate books and accounting records relating to the Project and the Services. Contractor will permit City to audit, examine, and make excerpts and transcripts from such books and records, and to make audits of all invoices, Materials, payrolls, records or personnel and other data related to all other matters covered by this Agreement, whether funded in whole or in part under this Agreement. Contractor shall maintain such data and records in an accessible location and condition for a period of not less than five years after final payment under this Agreement or until after final audit has been resolved, whichever is later. The State of California or any federal agency having an interest in the subject matter of this Agreement shall have the same rights as conferred upon City by this Section. Contractor shall include the same audit and inspection rights and record retention requirements in all subcontracts. The City's rights under this Section 4.6

(Audit and Inspection of Records) are in addition to the audit provisions stated in Appendix G (Federal Contract Requirements).

4.7. Submitting False Claims. The full text of San Francisco Administrative Code Chapter 21, Section 21.35, including the enforcement and penalty provisions, is incorporated into this Agreement. Pursuant to San Francisco Administrative Code §21.35, any contractor, Affiliate, or subcontractor who submits a false claim shall be liable to the City for the statutory penalties set forth in that section. A contractor, Affiliate or subcontractor will be deemed to have submitted a false claim to the City if the contractor, Affiliate, or subcontractor: (a) knowingly presents or causes to be presented to an officer or employee of the City a false claim or request for payment or approval; (b) knowingly makes, uses, or causes to be made or used a false record or statement to get a false claim paid or approved by the City; (c) conspires to defraud the City by getting a false claim allowed or paid by the City; (d) knowingly makes, uses, or causes to be made or used a false record or statement to conceal, avoid, or decrease an obligation to pay or transmit money or property to the City; or (e) is a beneficiary of an inadvertent submission of a false claim to the City, subsequently discovers the falsity of the claim, and fails to disclose the false claim to the City within a reasonable time after discovery of the false claim.

ARTICLE 5 WORK AND RESOURCES

5.1. Scope of Work. This Agreement provides the legal and procedural framework for Contractor's provision of the Services. Contractor agrees to perform the Work as generally described in this Agreement, and as more particularly described in Appendix A (Contract Specifications), including but not limited to design, procurement of Equipment, Materials and Software, oversight of Equipment installation, assistance with Legacy Systems integration, implementation and testing of the CBTC, providing Support Services, spare parts, Updates and Upgrades to the Software, and such Incidental Work as necessary to meet the requirements of and achieve the purposes of this Agreement. The Contractor will not perform any work that constitutes a public work or construction (that is, work that requires a California contractor's license), including the installation of wayside Equipment. The SFMTA will contract with third-party Installers to perform LRV and wayside Equipment installation. The Contract Specifications state System performance requirements. Except as expressly otherwise stated in this Agreement, the SFMTA is not specifying the means and methods by which Contractor will implement a System solution.

5.2. Exercise of Options. The SFMTA has eight (8) Options under this Contract. Options 1, 2 and 3 provide for Contractor's provision of additional Vehicle Equipment, as described in Contract Specifications, Section 2.4 (CBTC Fleet Options). Option 4 provides for purchase of additional Interlocking Equipment, as described in Contract Specifications Section 16.2 (System Architecture). Option 5 provides for purchase of additional Central Emergency Stop Buttons for Backup Control Center, as described in Contract Specifications Section 27.7.3 (Workstations). Option 6 provides for additional design services common to Heritage and/or Maintenance Vehicles, from PDR to Final Design. Options 7 and 8 are five-year extensions to the Support Term, as described in Article 3 (Contract Term). Contractor shall perform the Work described as Options in the referenced Contract provisions following written notice from the SFMTA.

5.3. Additional Work. Officers and employees of the City are not authorized to request, and the City is not required to reimburse Contractor for, Services beyond the Services described in this Agreement ("Additional Work") unless this Agreement is modified to include those Services in accordance with Section 12.5 (Contract Modifications and Change Orders).

5.4. Services Provided by Attorneys. Any services to be provided by a law firm or attorney to this Project must be reviewed and approved in writing in advance by the City Attorney. No invoices for services provided by law firms or attorneys, including, without limitation, as Affiliates or subcontractors of Contractor, will be paid unless Contractor and law firm or attorney have received advance written approval from the City Attorney.

5.5. Reports. Contractor shall submit written reports and other written Deliverables as requested by the SFMTA. Format for the content of such reports shall be determined by the SFMTA. The timely submission of all reports is a necessary and material term and condition of this Agreement. The reports, including any copies, shall be submitted electronically. When requested by SFMTA, report shall be printed on recycled paper and using double-sided pages to the maximum extent possible.

5.6. Department Liaison. Contractor's liaison with the SFMTA will be Dan Howard, SFMTA, 1455 Market Street, 7th floor, San Francisco, CA 94103; 415-646-4119; dan.howard@sfmta.com.

5.7. Parties' Roles and Responsibilities. Contractor's and City's respective obligations to implement the System are stated in this Agreement. The City's roles and responsibilities for the Project are expressly identified as City obligations; all other obligations stated in this Agreement are assigned to and are the responsibility of Contractor.

5.8. Contractor's Personnel

5.8.1. Qualified Personnel. Contractor shall use only competent personnel under the supervision of, and in the employment of, Contractor (or Contractor's authorized Affiliates and Subcontractors) to perform the Work. Contractor will comply with City's reasonable requests regarding assignment and/or removal of personnel, but all personnel, including those assigned at City's request, must be supervised by Contractor. Contractor shall commit adequate resources to allow timely completion within the "Days From NTP" column of the Milestone Schedule.

5.8.2. Key Personnel. The SFMTA selected Contractor in large part due to the particular experience and expertise of the Key Personnel listed below. Contractor shall provide the SFMTA not less than three-months' notice prior to reassigning Key Personnel. Contractor shall not reassign said personnel to other Projects or assignments without the express written approval of the SFMTA. Contractor agrees that the following Key Personnel shall be committed and assigned to provide Services under this Agreement to the level required by SFMTA for as long as necessary to complete the portions of the Work assigned to them, and said Key Personnel shall be located at the project office in San Francisco while assigned to the Project:

Ghislain LeDantec, Project Manager

Darryl Radstake, Lead Engineer

Nenad Boras, Lead Vehicle Engineer

Don Gonzales, System Assurance Manager

Irfan Siddiqui, Quality Assurance Manager

Anthony Daniel, Test and Commissioning Lead

Maryam Rahimi, Safety and Security Manager

Vadim Ayvazov, Technical Support Lead

5.8.3. Replacement of Key Personnel. Contractor shall replace existing Key Personnel only with persons with equal or better experience and expertise. All replacement Key Personnel are subject to the approval of the SFMTA, which will not be unreasonably withheld or unduly delayed. Contractor shall provide the SFMTA the complete resume (academic and work history) of proposed replacement Key Personnel not less than two weeks prior to their first day of work on this Contract. The SFMTA shall have no obligation to pay Contractor for any Work performed by replacement Key Personnel who the SFMTA have not approved.

5.8.4. Liquidated Damages for Unauthorized Replacement of Key Personnel. Contractor acknowledges that the SFMTA's selection of Contractor and negotiated compensation stated in the Contract Amount were based, in part, on the expertise and experience of Contractor's proposed Key Personnel as submitted in the Proposal. Contractor acknowledges and agrees that the replacement of Key Personnel during the course of the Project would be extremely disruptive and damaging to the City, the cost of which is difficult, if not impossible, to calculate. Contractor, therefore, shall pay to the City a charge of Five Hundred Thousand Dollars ($500,000) for the first Key Personnel whom Contractor reassigns without written approval by the City. For each additional Key Personnel whom Contractor reassigns without written approval by the City, Contractor shall pay to the City a charge of Six Hundred Thousand Dollars ($600,000). Said charges shall not be considered or act as a penalty, but shall be liquidated damages to the City to compensate the City for the additional costs and inefficiencies to the Project that the Parties agree will necessarily arise from the unauthorized departure of Key Personnel. Should the City require Contractor to replace or reassign any of its personnel so that said persons are no longer working on the Project, the liquidated damages provisions of this Section 5.8.4 shall not apply.

5.8.5. Key Personnel Training Period. If the SFMTA approves Contractor's request to reassign any Key Personnel, Contractor shall provide a training period of not less than four weeks during which the departing Key Personnel will train their replacement on the aspects of the Project for which they will be responsible. If Contractor is replacing Key Personnel who have left Contractor's employment, Contractor shall provide as much training as is feasible between the date Contractor was notified of the departure and the day of termination of the departing Key Personnel's employment with Contractor, during which the departing Key Personnel will train their replacement on the aspects of the Project for which they will be responsible. Contractor shall bear all expenses arising from the replacement of Key Personnel, including but not limited to the salary costs of the replacement Key Personnel during the training period.

5.8.6. Reassignment of Personnel. The SFMTA reserves the right to require Contractor to reassign (remove) from the Project any person under Contractor's control (including employees, Affiliates, subcontractors, and consultants) if the SFMTA is unsatisfied with that person's performance, is offensive, or fails to demonstrate the required qualifications or expertise necessary to perform the Work.

5.8.7. Current Workload and Available Resources. Contractor shall ensure that its other projects, contracts, and obligations do not limit the availability of Contractor's personnel and resources necessary for Contractor to perform the Work and complete the Project and its Milestones and subordinate tasks, within the periods specified or otherwise provided in this Agreement and Contract Schedule. Requirements concerning the development, review and update of the Contract Schedule are set out in Contract Specifications, Section 3.2.4 (Schedules). Contractor shall ensure that its personnel, Affiliates, and subcontractors necessary to perform particular tasks or portions of the Services are available to perform their assigned parts of the Services in accordance with the Contract Schedule.

5.9. Transmittal of Work Product. When requested by the SFMTA, the Contractor shall transmit to Agency all work product produced or accumulated in the course of its and its Subcontractors' and Affiliates' work on this Agreement. The Contractor's Project Manager and Key Personnel shall have thoroughly reviewed and approved the work product prior to transmitting it to Agency. Contractor may retain copies of work product for its own reference, but for no other purpose.

5.10. Subcontracting

5.10.1. Subcontracts. Contractor may subcontract portions of the Work only upon prior written approval of City. Portions of Work subcontracted to Affiliates are not subject to said prior written approval, but the Contractor must notify the SFMTA of the identity of each

Affiliate before it begins to perform Work on the Contract. Contractor shall closely monitor and is responsible for its Subcontractors' and Affiliates' performance of Work. All subcontracts must incorporate the terms of Article 11 (Additional Requirements Incorporated by Reference) of this Agreement. Neither Party shall contract on behalf of, or in the name of, the other Party to perform any Work under this Agreement. Any agreement made in violation of this provision shall be null and void.

5.10.2. List of Subcontractors. City's execution of this Agreement constitutes its approval of the Subcontractors listed below.

Syntony SAS

Anta Electric

SacTown Logistics, LLC

Clark Transportation Consulting & Services, LLC DBA Bison Rail Systems

Accio Ads LLC dba Veterans Logistics Group

5.11. Independent Contractor; Payment of Employment Taxes and Other Expenses

5.11.1. Independent Contractor

(a) For the purposes of this Section 5.11, "Contractor" shall be deemed to include not only Contractor, but also any agent or employee of Contractor. Contractor acknowledges and agrees that at all times, Contractor or any agent or employee of Contractor shall be deemed at all times to be an independent contractor and is wholly responsible for the manner in which it performs the services and work requested by City under this Agreement.

(b) Contractor, its agents, and employees will not represent or hold themselves out to be employees of the City at any time. Contractor or any agent or employee of Contractor shall not have employee status with City, nor be entitled to participate in any plans, arrangements, or distributions by City pertaining to or in connection with any retirement, health or other benefits that City may offer its employees. Contractor or any agent or employee of Contractor is liable for the acts and omissions of itself, its employees and its agents. Contractor shall be responsible for all obligations and payments, whether imposed by federal, any state or local law, including, but not limited to, FICA, income tax withholdings, unemployment compensation, insurance, and other similar responsibilities related to Contractor's performing services and work, or any agent or employee of Contractor providing same. Nothing in this Agreement shall be construed as creating an employment or agency relationship between City and Contractor or any agent or employee of Contractor.

(c) Any terms in this Agreement referring to direction from City shall be construed as providing for direction as to policy and the result of Contractor's work only, and not as to the means by which such a result is obtained. City does not retain the right to control the means or the method by which Contractor performs work under this Agreement.

(d) Contractor agrees to maintain and make available to City, upon request and during regular business hours, accurate books and accounting records demonstrating Contractor's compliance with this Section.

5.11.2. Payment of Employment Taxes and Other Expenses. Should City, in its discretion, or a relevant taxing authority such as the Internal Revenue Service or the State Employment Development Division, or both, determine that Contractor is an employee for purposes of collection of any employment taxes, the amounts payable under this Agreement shall be reduced by amounts equal to both the employee and employer portions of the tax due (and offsetting any credits for amounts previously paid by Contractor which can be applied against

this liability). City shall then forward those amounts to the relevant taxing authority. Should a relevant taxing authority determine a liability for past services performed by Contractor for City, upon notification of such fact by City, Contractor shall promptly remit such amount due or arrange with City to have the amount due withheld from future payments to Contractor under this Agreement (again, offsetting any amounts already paid by Contractor which can be applied as a credit against such liability). A determination of employment status pursuant to this Section 4.8 shall be solely limited to the purposes of the particular tax in question, and for all other purposes of this Agreement, Contractor shall not be considered an employee of City. Notwithstanding the foregoing, Contractor agrees to indemnify and save harmless City and its officers, agents and employees from, and, if requested, shall defend them against any and all claims, losses, costs, damages, and expenses, including attorneys' fees, arising from this Section.

5.12. Assignment. The Work that Contractor shall perform under this Agreement are personal in character. Neither this Agreement nor any duties or obligations hereunder may be directly or indirectly assigned, novated, hypothecated, transferred, or delegated by Contractor, or where Contractor is a joint venture, a joint venture partner (collectively referred to as an "Assignment"), unless first approved by City by written instrument executed and approved as required under City law and under the policy of the SFMTA Board of Directors. The City's approval of any such Assignment is subject to Contractor demonstrating to City's reasonable satisfaction that the proposed transferee is: (a) reputable and capable, financially and otherwise, of performing each of Contractor's obligations under this Agreement and any other documents to be assigned, (b) not forbidden by applicable law from transacting business or entering into contracts with City; and (c) subject to the jurisdiction of the courts of the State of California. Contractor shall immediately notify City about any Assignment. Any purported Assignment made in violation of this provision shall be null and void. (See also Section 5.20 ("Business Discontinuation.")

5.13. Standard of Care. Contractor agrees that the design and implementation of the CBTC are specialized engineering services. The standard of care applicable to the Contractor shall be that the Services will be performed with the degree of skill and care that is required by current, good and sound professional procedures and practices, and in conformance with generally accepted professional standards applicable to communications based train control systems and other passenger rail train control systems prevailing at the time the Services are performed, so that all Services that Contractor provides are correct and appropriate for the purposes contemplated in this Agreement. Said standards shall conform to IEEE 1474 series and applicable AREMA standards.

5.14. Notice of Deficiency and Demand to Cure. Should City determine that Contractor, or any agent or employee of Contractor, is not performing in accordance with the requirements of this Agreement, City shall provide Contractor with written notice of such failure. Within five business days of Contractor's receipt of such notice, and in accordance with Contractor policy and procedure, Contractor shall remedy the deficiency or present a plan to remedy the deficiency that is acceptable to the City. Notwithstanding, if City believes that an action of Contractor, or any agent or employee of Contractor, warrants immediate remedial action by Contractor, City shall contact Contractor and provide Contractor in writing with the reason for requesting such immediate action.

5.15. Equipment and Software Warranties. Contractor's warranty obligations are described in Contract Specifications, Section 13 (Warranty and Spare Parts).

5.16. Delivery of Equipment, Software and Materials

5.16.1. Delivery of Fitment. Contractor shall deliver all Equipment and procured Materials to the SFMTA according to the Contract Schedule to ensure that the Equipment and procured Materials needed for Fitment are available to the Installers before said Equipment and Materials are needed for Installation. Contractor shall be subject to Liquidated Damages

described in Section 5.18.11 (Liquidated Damages for Late Delivery) arising from or related to Contractor's later delivery to the SFMTA of Equipment and procured Materials.

5.16.2. Transfer of Title. Title of all Equipment and procured Materials shall transfer to the SFMTA upon the SFMTA's payment for the item(s), irrespective of possession of said item(s) and irrespective of whether the SFMTA has conditionally accepted the items. Payment for Equipment, Software, and procured Materials shall not constitute acceptance of the item(s) and is not a waiver of any requirement of the Contract.

5.16.3. Risk of Loss. Contractor shall bear all risk of loss of Equipment, Software and other Contractor-procured Materials, including any damage or loss sustained during transportation from Contractor's (or its supplier's) point of origin, until the SFMTA accepts in writing the delivery of the Equipment, Software and Materials. Until written acceptance of delivery, Contractor shall insure all Equipment, Software and Materials against damage and loss, regardless of whether said items are in Contractor's possession, in transit, or in the SFMTA's possession. See Section 6.1 (Insurance and Indemnity).

5.17. Project Schedule

5.17.1. Schedules. Contractor shall prepare, maintain and update the Project Schedule as provided in Contract Specifications, Section 3.2.4 (Schedules).

5.17.2. Wayside Work Moratorium; Interference with Transit Operations. For any Work that Contractor performs, including System testing, that requires a Closure or is Work performed on the wayside, in Stations, or on platforms that may interfere with Revenue Service, Contractor shall schedule that Work in accordance with the requirements for track, tunnel and wayside access provided in Appendix J, Item 1 (Track and Tunnel Access Procedures). Contractor shall confer with SFMTA in planning its Project Schedule and schedule updates to confirm that Contractor's planned Work activities will not interfere with Revenue Service, other transit operations, transit infrastructure maintenance and repairs, and other SFMTA activities.

5.17.3. Incidental Work. Contractor's costs and or time expended related to or arising from planning, scheduling, and coordinating Closures to accommodate holiday moratorium periods, Revenue Service and other transit operations are Incidental Work for which Contractor shall not receive additional compensation.

5.18. Delay, Force Majeure, and Liquidated Damages

5.18.1. Delay. Time is of the essence in Contractor's performance of the Work. See Section 12.15 (Time is of the Essence). By entering into this Agreement, Contractor agrees that in the event the progress or completion of the Work is delayed beyond the scheduled Milestones and other Work completion deadlines as provided in the approved Contract Schedule, as may be revised by Contract Modifications, City will suffer damages that will be impracticable or extremely difficult to determine. Contractor further agrees that the amounts listed as liquidated damages in the Agreement for each Day or hour of delay beyond scheduled Milestones and timelines are not a penalty but are a reasonable estimate of the loss that City will incur based on the delay, established in light of the circumstances existing at the time this Contract was Awarded. Except where the delay is the result of an Unavoidable Delay, City may deduct a sum representing said liquidated damages from any money due to Contractor (including Retained Funds). Such deductions shall not be considered a penalty but are agreed monetary damages and compensation for losses the City has sustained because of Contractor's failure to deliver the Work or specified element of the Work to City within the time stated in the Agreement, as it may be amended.

5.18.2. Unavoidable Delay. An Unavoidable Delay is an interruption of the Work beyond the control of Contractor, which Contractor could not have avoided by the exercise of care, prudence, foresight, and diligence. Such delays include and are limited to (1) Force

Majeure Events; (2) changes in the Work ordered by the City insofar as they necessarily require additional time in which to complete the entire Work; (3) delays caused by the City of Contractor's commencing or performing the Work; or (4) delays caused by Installers or other contractors employed by the City insofar as Contractor does not contribute to the delays. The duration of said Unavoidable Delays shall be limited to the extent that the commencement, prosecution, and completion of the Work are delayed thereby.

5.18.3. Notification of Delay. Contractor shall notify SFMTA as soon as Contractor has, or should have, knowledge that an event has occurred that will delay the Work beyond Milestones or the Project Final Completion date. Within 10 Days, Contractor shall confirm such notice in writing, furnishing as much detail as is available, including whether the Contractor asserts that: (1) the delay was caused by a Force Majeure Event; or (2) the City is liable for the delay.

5.18.4. Request for Extension. After notification of the delay, Contractor shall submit claims for compensation and extension of time through a Request for Contract Change under the procedure set forth in Appendix E (Clarifications and Changes in the Work). The granting of an extension of time because of Unavoidable Delays for a specific delay shall in no way operate as a waiver on the part of the City of the right to collect liquidated damages for other delays or of any other rights to which the City is entitled for other delays.

5.18.5. Liability. For an Unavoidable Delay that is caused, directly or indirectly, by a Force Majeure Event, the affected Party will be entitled to an extension of time in accordance with Section 5.18.6 below, and will not be entitled to additional compensation. For all other Unavoidable Delays described in Section 5.18.2 above, Contractor shall be entitled to an equitable adjustment to the Contract Term and/or an increase in the Contract Amount to the extent the delay is caused by the SFMTA, its Installers or its other contractors. In the case of a Force Majeure Event, Contractor shall immediately commence disaster recovery services as described in Section 5.18.8 (Disaster Recovery).

5.18.6. Duration. In a Force Majeure Event, the non-performing Party shall be excused from further performance or observance of the obligation(s) so affected for as long as such circumstances continue and such Party continues to use its best efforts to recommence performance or observance whenever and to whatever extent possible without delay. Any Party so delayed in its performance shall notify the Party to whom performance is due by telephone as soon as it becomes aware of the Force Majeure Event (to be confirmed in writing within five (5) days of the notification of such delay) and describe at a reasonable level of detail the circumstances causing such delay.

5.18.7. Effect. If a Force Majeure Event substantially prevents, hinders, or delays performance of the Services as critical for more than one hundred and twenty (120) consecutive Days, then the City may: (i) terminate any portion of this Agreement so affected in accordance with the provisions set forth in Section 9.1 Termination for Convenience; or (ii) terminate this Agreement without liability to City or Contractor as of a date specified by City in a written notice of termination to Contractor. Contractor shall not have the right to any additional payments from City for costs or expenses incurred by Contractor as a result of any force majeure condition that lasts longer than three (3) days.

5.18.8. Disaster Recovery. Contractor shall provide disaster recovery services in accordance with the provisions of the Disaster Recovery Plan contained in the Project Management Plan (see Contract Specifications, Section 3.2.3) or as otherwise set forth in this Agreement. A Force Majeure Event shall not excuse Contractor of its obligations for performing disaster recovery services as provided in this Agreement.

5.18.9. Liquidated Damages for Transit Service Interruption. The SFMTA will operate Revenue Service throughout the Contract Term (in both the Procurement Term and Support Term) on rail lines on which or in close proximity to areas where Contractor will need to

perform Work. The SFMTA and Contractor must carefully coordinate Contractor's performance of the Services to minimize disruption of transit services. The SFMTA will schedule temporary rail service suspensions ("Closures") of portions of its rail network to accommodate Contractor's performance of the Services, in accordance with permits and clearances requested by Contractor and granted by SFMTA. A Closure will significantly impact public transit services. A Closure will require the SFMTA to limit or completely suspend transit service along an affected rail line and will require the SFMTA to expend substantial resources to plan and to perform community outreach and manage public relations to inform affected passengers and neighborhoods prior to a Closure, and to plan, resource, and staff alternate transit services (including bus bridges). In consideration of those expenditures and other costs, damages and impacts, the value of which would be difficult or impossible to calculate at the time of Contractor's failure to provide timely notice of a Closure or delay in returning a rail line to Revenue Service following a Closure, the liquidated damages provided below do not constitute a penalty but represent a fair estimate of the damages the SFMTA will incur and impacts to the public arising from said lack of timely notice or delay, in light of the circumstances and facts known at the time of Contract Award.

(a) **Liquidated Damages for Requesting Closures on Short Notice.** Contractor shall request Closures as provided in the SFMTA Track and Tunnel Access Procedures in Appendix J (SFMTA Policies and Procedures). As provided in those Track and Tunnel Access Procedures, Contractor shall request a Closure not less than 180 Days in advance of the requested Closure date, (or within such time prescribed in the version of the Track and Tunnel Access Procedures in effect at time of the request), so that the SFMTA has adequate time to evaluate impacts on transit service, plan for alternate service, and inform the public of the dates and times of each Closure. In the event that Contractor requests a Closure or modifies a request for a Closure such that the dates and times of the Closure change from those specified in the original request, and that new request or modification results in the SFMTA having fewer than the minimum number of Days specified in the SFMTA Track and Tunnel Access Procedures, Contractor shall pay liquidated damages in the amount of Thirty-Five Thousand Dollars ($35,000).

(b) **Liquidated Damages for Exceeding Closure Period.** Contractor shall manage its work and perform the Services during a Closure to ensure that the closed rail line is reopened to Revenue Service as scheduled in the Closure permit. In the event that Contractor does not vacate a trackway or rail line as scheduled or occupies a trackway or rail line or otherwise interferes with and delays the SFMTA's re-opening a rail line or trackway to Revenue Service beyond the time stated in a Closure permit Contractor shall pay the SFMTA the sum(s) stated in the following Liquidated Damages Schedule:

Delay Period	LD Value $
First hour (or fraction thereof)	$35,000
Two hours or less	$40,000
Four hours or less	$50,000
Over 4 hours	$100,000
For each additional Day	$100,000

(c) **Liquidated Damages for Cancelling or Postponing a Closure.** Contactor acknowledges and agrees that a Closure is a significant event that may require the SFMTA to expend substantial resources to plan, schedule and staff alternate transit services

(such as bus bridges) to maintain minimum transit services during a Closure, and to perform community outreach and manage public relations to inform affected passengers and neighborhoods prior to a Closure. In consideration of those and other costs, damages and other impacts that are difficult or impossible to calculate, if Contractor cancels or otherwise postpones the commencement of a Closure as specified for which the SFMTA has already expended planning resources and provided notice of the Closure to the public, Contractor shall pay to the SFMTA the sum of Fifty Thousand Dollars ($50,000) as compensation for the SFMTA's costs to inform the public and provide resources to inform the public of the delay to the Closure and/or reschedule the Closure.

5.18.10. Liquidated Damages for Project Delays. A fully functioning train control system is critical to the SFMTA's providing safe and efficient transit services. The intent and purpose of this Agreement is to procure and implement a CBTC to replace of the SFMTA's existing train control system (ATCS), which due to age is deteriorating, resulting in ATCS equipment malfunctions and ATCS outages that delay and otherwise impact transit service. If Contractor delays the final completion of the Project or delays completion of Project Milestones, the SFMTA will suffer damages arising from continuing and additional delays and other impacts to transit service caused by ATCS malfunctions and downtime that would have been avoided but for said Contractor delays. Said damages would be impractical or extremely difficult to calculate at time the delay occurs, which involve loss of public use, loss of fare revenue, and loss of the SFMTA's reputation in addition to the direct labor, equipment, and administrative costs that the SFMTA would incur in operating its rail transit services in manual mode and providing alternate transit services. Contractor therefore agrees that the SFMTA may assess liquidated damages for said Contractor's delays, as set out in the following sections. Said liquidated damages do not constitute a penalty but are a reasonable estimate of the losses that City will incur arising from delay, based on the information available and the circumstances existing at the time this Agreement was Awarded.

(a) In the event that the Subway Cutover Date (Milestone 5.7) is delayed by Contractor beyond the date stated in the approved Milestone Schedule, the City will suffer actual damages that will be impractical or extremely difficult to determine. Contractor therefore agrees that it will pay the SFMTA the sum of Forty Thousand Dollars ($40,000) for each Day the scheduled Subway Cutover is delayed.

(b) In the event that the Final Commissioning Date (Milestone 10.7) is delayed by Contractor beyond the date stated in the approved Milestone Schedule, the City will suffer actual damages that will be impractical or extremely difficult to determine. Contractor therefore agrees that it will pay the SFMTA the sum of Thirty Thousand Dollars ($30,000) for each Day the scheduled Final Commissioning Date is delayed.

5.18.11. Liquidated Damages for Late Delivery. Even though Contractor will not perform installation services, timely installation of the system is dependent on Contractor's timely completion of its delivery obligations under the Contract. If delivery of Equipment or Materials is delayed beyond the date specified for the delivery in the approved Project Schedule under Contract Specification section 3.2.4.2, Project Schedule, the SFMTA will suffer damages, including delay claims against the SFMTA from its Installers and the postponement of scheduled Closures for installation work, that will be impractical or extremely difficult to determine. Contractor therefore agrees that it will pay the SFMTA the sum of Fifty Thousand Dollars ($50,000) for each Day that the scheduled delivery of a shipment of Equipment or Materials is delayed.

5.18.12. General Liquidated Damages Provisions

(a) City may deduct a sum representing assessed liquidated damages from any money due to Contractor under this Agreement (including Retained Funds).

(b) The SFMTA will not assess liquidated damages that cause the total liquidated damages assessed during the Procurement Term to exceed an aggregate limit of 10 percent of the Total System Procurement Price, as stated in Table 1 of Appendix B, as that amount may be modified by approved Contract Modifications and the SFMTA's exercise of Procurement Options in Table 2 of Appendix B. The SFMTA will not assess liquidated damages that cause the total liquidated damages assessed during the Support Term to exceed an aggregate limit of 10 percent of the Total Support Fee (See Appendix B, Table 3 (System Support Prices), Column D (Maximum Support Fee) (Schedule of Prices and Calculation of Charges), as the Total Support Fee may be amended by approved Contract Modifications and the SFMTA's exercise of Options to extend the Support Term. Liquidated Damages shall be the sole and exclusive remedy for the SFMTA for delay until the limits calculated under this section are exceeded.

(c) If the total amount of liquidated damages accrued by Contractor exceeds the limits stated in the preceding Section 5.18.12.2, this shall constitute a material breach of this Agreement, which the SFMTA may deem to be an Event of Default. See Section 9.2 (Termination for Default; Remedies).

(d) Contractor's payment of liquidated damages under any provision of this Contract shall not relieve Contractor from separate liability for liquidated damages under the other provision(s) of the Contract, each to the full extent of the specified amount, regardless of whether the times for which liquidated damages are to be paid do or do not run concurrently, or whether each liability is or is not a consequence of the other.

(e) The SFMTA's right to assess liquidated damages under the Contract does not reduce or compromise the SFMTA's rights to terminate the Contract for cause for excessive liquidated damages in accordance with Section 5.18.12.3, to terminate for convenience, to demand that Contractor cure any breach of the Contract, or to seek performance of the Contract under any bond that guarantees the performance of the Contract.

5.19. Bond Requirements.

5.20. Business Discontinuation. Contractor agrees that in the event it exits the train control business or otherwise ceases to market and/or ceases to provide maintenance and support services to the SFMTA and other transit agencies that utilize Contractor's CBTC systems, and Contractor has no successor in interest by merger, operation of law, assignment, purchase, or otherwise, notwithstanding any other remedy that that the City may have under the Agreement or at law, Contractor shall provide City not less than 24 months' notice prior to ceasing operations and Support, and shall make available to the SFMTA all Equipment that the SFMTA determines that it will require to operate the CBTC for whatever period the SFMTA may determine is necessary to procure and cutover to another train control system. Contractor shall also under those circumstances provide the SFMTA without charge, one (1) copy of the then-current Source Code for all of the programs and all supporting Documentation for the Software then operating in the CBTC. If City should obtain the Source Code and the Documentation pursuant to this Section 5.20, the only use made of the Source Code and the Documentation will be for the operation and maintenance of the CBTC in connection with City's use of the CBTC as provided for, and limited by, the provisions of this Agreement.

ARTICLE 6 INSURANCE AND INDEMNITY

6.1. Insurance. Without in any way limiting Contractor's liability pursuant to the "Indemnification" provisions of this Agreement (see Article 7, Liability of the Parties), Contractor shall maintain in full force and effect the insurance as described in this Article from the Effective Date of this Agreement until this Agreement expires or is terminated, with the minimum specified coverages stated below or as required by applicable laws and regulations, whichever is greater. Subject to approval by the City's Risk Manager, Contractor may use umbrella insurance policies to supplement primary insurance policies or other established

insurance programs, provided that the protection afforded to the City by such alternate insurance programs and the aggregate coverage for any claim is not reduced below the coverage levels specified herein. Subject to approval by the City's Risk Manager, if the specified insurance coverage would result in Contractor obtaining duplicative coverage, subject to proof, Contractor may combine species of coverage under a single policy. All coverage amounts are listed in United States Dollars.

6.1.1. Worker's Compensation Insurance. Contractor shall provide workers compensation insurance in statutory amount, including Employers' Liability coverage with limits not less than $2,000,000 each accident, injury, or illness, including coverage, as Contractor determines to be applicable, for U.S. Long Shore and Harbor Workers' Act benefits and Jones Act benefits, and Federal Employers Liability Act. The Worker's Compensation policy shall be endorsed with a waiver of subrogation in favor of the City for all work performed by Contractor, its employees, agents, Affiliates, and subcontractors.

6.1.2. Commercial General Liability Insurance. Contractor shall provide commercial general liability (CGL) insurance with coverage limits not less than One-Hundred Million Dollars ($100,000,000) each occurrence, and One-Hundred Million ($100,000,000) annual aggregate, for bodily injury and property damage, including coverage for Contractual Liability, Personal Injury, Products, Completed Operations, independent Contractor, Explosion, Collapse, and Underground (XCU). and property damage, including coverage for Contractual Liability. Said CGL policy shall not contain any limitation or exclusion that would preclude a claim provided for by the Article 6 (Insurance and Indemnity) or Article 7 (Liability of the Parties) of this Agreement. Administrative costs of claims, including but not limited to legal costs and attorney's fees, shall not be accounted against or otherwise reduce the value of the insurance available to cover an insured loss. Should a claim or claims be paid by said policy that total(s) in the aggregate more than $5,000,000, Contractor shall within ten (10) Days of receipt of such claim(s) provide notice of same to the SFMTA and obtain additional insurance so that Contractor's Work under Agreement is at all times fully covered as specified herein.

6.1.3. Commercial Automobile Liability Insurance. Contractor shall provide Commercial Automobile Liability Insurance with limits not less than Five Million Dollars ($5,000,000) each occurrence combined single limit for Bodily Injury and Property Damage, including Owned, Hired Or Non-Owned vehicles coverage, as applicable.

6.1.4. Risk of Loss Insurance. Contractor shall insure Equipment, Software and procured Materials against loss for full replacement value, including shipping costs, until the City's Conditional Acceptance of the Equipment following its installation and Commissioning to Revenue Service in a completed Phase. Said insurance shall cover against all losses of Equipment, Software and Materials in transit and in storage, until the SFMTA has taken possession of them, regardless of whether title has transferred to the SFMTA. Contractor shall provide Bailee's Insurance in a form appropriate for the nature of City property in the care, custody, or control of Contractor, on an all-risk form, for the total (100%) of the replacement value of the stored items. Contractor shall provide Cargo Insurance in a form appropriate for the nature of City property while in transit, on an all-risk form for the total (100%) replacement value of the shipped items. See Section 5.16.3 (Risk of Loss).

6.1.5. Professional Liability Insurance. Contractor shall provide Professional Liability Insurance applicable to Contractor's profession, with limits not less than Twenty Five Million Dollars ($25,000,000) for each claim with respect to negligent acts, errors or omissions in connection with the Work.

6.1.6. Technology Errors and Omissions Liability. Contractor shall provide Technology Errors and Omissions Liability Insurance with limits of Fifty Million Dollars ($50,000,000) for each claim and each loss. The policy shall at a minimum cover professional misconduct or lack of the requisite skill required for the performance of the Work and shall also provide coverage for the following risks:

(a) Network security liability arising from the unauthorized access to, use of, or tampering with computers or computer systems, including hacker attacks; and

(b) Liability arising from the introduction of any form of malicious software including computer viruses into, or otherwise causing damage to the CBTC System, the City's or third person's computer, computer system, network, or similar computer related property and the data, software, and programs thereon.

6.1.7. Cyber Insurance. Contractor initially shall provide Cyber Insurance with limits of not less than Ten Million Dollars ($10,000,000) per claim. The Cyber Insurance limits shall be increased to Fifty Million Dollars ($50,000,000) before installation of the primary Central Control Equipment (Milestone 2-1 as described in Appendix C). Such insurance shall include coverage for liability arising from theft, dissemination, and/or use of Confidential Information, including Security Sensitive Information and Critical Infrastructure Information. The City will not accept delivery of the Central Control Equipment until the Contractor furnishes to City evidence of the required increased coverage consistent with the requirements of Section 6.1.12.5 below.

6.1.8. Railroad Protective Liability Insurance. Contractor shall provide Railroad Protective Liability Insurance with limits of not less than Ten Million U.S. Dollars ($10,000,000) per occurrence and Ten Million U.S. Dollars ($10,000,000) in the aggregate annually for losses arising out of bodily injury to or death of all persons, and for physical loss or damage to or destruction of property, including the loss or use thereof. Coverage shall apply to Contractor's activities and operations performed within 50 feet vertically or horizontally of the centerline of BART's tracks, and of SFMTA Muni tracks, and of the Caltrain/Union Pacific rights-of-way. The language of said policy is subject to the approval of BART and the City's Risk Manager.

6.1.9. Waiver of Subrogation. The Workers' Compensation policy(ies) shall be endorsed with a waiver of subrogation in favor of the City for claims arising from or related to any Work performed by Contractor, its employees, agents, Affiliates, and subcontractors.

6.1.10. Additional Insured Entities

(a) Contractor's General Liability policies shall include the following entities as Additional Insureds to which Contractor owes a duty of indemnity and defense from claims and lawsuits, as provided in Section 6.2 (Indemnification):

(1) City and County of San Francisco, its board members and commissions, and all authorized agents and representatives, and members, directors, officers, trustees, agents, and employees of any of them.

(2) Bay Area Rapid Transit District (BART) and its board members, and all authorized agents and representatives, and members, directors, officers, trustees, agents, and employees of BART.

(b) Contractor's Commercial Automobile Insurance policies shall include the City and County of San Francisco, its board members and commissions, and all authorized agents and representatives, and members, directors, officers, trustees, agents, and employees of any of them as Additional Insureds to which Contractor owes a duty of indemnity and defense from claims and lawsuits, as provided in Section 6.2 (Indemnification).

6.1.11. Primary Insurance Endorsements

(a) The Commercial General Liability policy shall provide that such policies are primary insurance to any other insurance available to the Additional Insureds, with respect to any claims arising out of this Agreement, and that the insurance applies separately to each insured against whom claim is made or suit is brought.

(b) The Commercial Automobile Liability Insurance policy shall provide that such policies are primary insurance to any other insurance available to the Additional Insureds, with respect to any claims arising out of this Agreement, and that the insurance applies separately to each insured against whom claim is made or suit is brought.

6.1.12. Other Insurance Requirements

(a) All insurance policies required to be maintained by Contractor under this Agreement shall be endorsed to provide for thirty (30) Days prior written notice to the City of cancellation for any reason, intended non-renewal, or reduction in coverage. Said notices shall be sent to the persons and addresses list in Section 12.1 (Notices to the Parties). Contractor, upon notification of receipt by the City of any such notice, shall submit to the City a certificate of the required new or renewed policy at least 10 Days before the effective date of such cancellation, change or expiration, with a complete copy of new or renewed policy.

(b) Should any of the required insurance be provided under a claims-made form, Contractor shall maintain such coverage continuously throughout the Contract Term and, without lapse, for a period of three years beyond the expiration of this Agreement, to the effect that, should occurrences during the Agreement term give rise to claims made after expiration of the Agreement, such claims shall be covered by such claims-made policies.

(c) Should any of the required insurance be provided under a form of coverage that includes a general annual aggregate limit or provides that claims investigation or legal defense costs be included in such general annual aggregate limit, such general annual aggregate limit shall be double the occurrence or claims limits specified above.

(d) Should any required insurance lapse during the Contract Term, requests for payments originating after such lapse shall not be processed until the City receives satisfactory evidence of reinstated coverage as required by this Agreement, effective as of the lapse date. If insurance is not reinstated, the City may, in its sole discretion, suspend all Work at no cost to the City until such time as Contractor provides sufficient evidence that such insurance has been reinstated from the date that the insurance lapsed, or the City may terminate this Agreement effective on the date of such lapse of insurance.

(e) Within 15 Days of the Notice of Award of this Agreement, and before commencing any of the Work, Contractor shall furnish to City certificates of insurance and additional insured policy endorsements, in form evidencing all coverages set forth above. Approval of the insurance by City shall not relieve or decrease Contractor's liability hereunder.

(f) If Contractor will use any Affiliate(s) or subcontractor(s) to perform the Work, Contractor shall require the Affiliate(s) or subcontractor(s) to provide all necessary insurance and to name the City and County of San Francisco, its officers, agents and employees and Contractor as additional insureds.

(g) If Contractor is a joint venture partnership, each partner shall be jointly and severally liable for claims arising under or related to this Agreement, and no insurance policy providing coverage under this Agreement shall contain any provision prohibiting coverage of a joint venture partnership or otherwise limiting coverage of any joint venture partner or to any joint venture partner.

6.1.13. Insurer Qualifications. Insurance companies providing coverage for this Agreement shall be legally authorized to engage in the business of furnishing insurance in the State of California. All insurance companies shall have a current A.M. Best Rating not less than "A-,VIII" and shall be satisfactory to the City.

6.2. Indemnification

6.2.1. To the fullest extent permitted by California law, Contractor shall indemnify and hold harmless City and its officers, agents and employees from, and shall defend

them from and against any and all claims, demands, losses, damages, costs, expenses, and liability for injury to or death of a person, including employees of City or Contractor; or loss of or damage to property to the extent caused by or arising from Contractor's negligent performance of this Agreement or willful misconduct, including, but not limited to, Contractor's use of facilities or equipment provided by City or others, except to the extent that such indemnity is void or otherwise unenforceable under applicable law, and except where such loss, damage, injury, liability or claim is the result of the active negligence or willful misconduct of City and is not contributed to by any act of, or by any omission to perform some duty imposed by law or agreement on Contractor, its Affiliates, Subcontractors, or either's agent or employee. The foregoing indemnity shall include, without limitation, reasonable fees of attorneys, Contractors and experts, investigation costs, and related costs directly arising from said claim(s).

6.2.2. In addition to Contractor's obligation to indemnify City, Contractor specifically acknowledges and agrees that it has an immediate and independent obligation to defend City from any claim which actually or potentially falls within this indemnification provision, even if the allegations are or may be groundless, false, or fraudulent, which obligation arises at the time such claim is tendered to Contractor by City and continues at all times thereafter.

6.2.3. The indemnification stated in this Section 6.2 (Indemnification) is subject to the City: (i) providing Contractor with prompt written notice of the claim; (ii) granting Contractor sole control of the defense to the claim, except that Contractor may not enter into any settlement that would adversely impact the City's rights or impose liability upon the City without the written consent of the City Attorney and the Director of Transportation (and the SFMTA Board of Directors, as applicable); and, (iii) providing reasonable cooperation in the defense of the claim, provided that the City shall not incur any expenses.

6.2.4. The terms, conditions, provisions, and failure to cover of any insurance policy covering Contractor's performance and obligations under this Agreement shall not operate to limit Contractor's Liabilities under this Agreement, nor shall the amount of insurance coverage operate to limit the extent of such Liabilities.

6.2.5. Contractor shall also indemnify and defend the Bay Area Rapid Transit District (BART) from premises liability claims and other lawsuits from third parties arising from Contractor's performance of the Services.

6.3. Intellectual Property Infringement

6.3.1. Contractor shall indemnify, defend and hold fully harmless City from all suits or claims for infringement of the patent rights, copyright, trade secret, trade name, trademark, service mark, or any other intellectual property claims or proprietary right of any person or persons in consequence of the use by City (and any Indemnitees) of any Equipment, Software, Applications, Deliverables, data or other items (Items) supplied or procured by Contractor for or in the performance of Services.

6.3.2. Infringement of patent rights, copyrights, or other proprietary rights in the performance of this Agreement, if not the basis for indemnification under the law, shall nevertheless be considered a material breach of contract.

6.3.3. To cure breach of this provision, Contractor shall at its sole expense and election, provided any such election does not result in any cost to the City, either: (1) indemnify the City; (2) obtain the right to use the infringing Item; or (3) modify the infringing Item so that it becomes non-infringing; or (4) replace the infringing Item with a non-infringing item that meets the requirements of this Agreement.

6.3.4. The indemnification stated in this Section 6.3 (Intellectual Property Infringement) is subject to the City: (i) providing Contractor with prompt written notice of the claim; (ii) granting Contractor sole control of the defense to the claim, except that Contractor

may not enter into any settlement that would adversely impact the City's rights or impose liability upon the City without the written consent of the City Attorney and the Director of Transportation (and the SFMTA Board of Directors, as applicable); and, (iii) providing reasonable cooperation in the defense of the claim, provided that the City shall not incur any expenses.

6.3.5. Contractor shall have no obligations with respect to intellectual property infringements caused by: (1) Contractor's compliance with City's designs (which shall not include City-approved Contractor's designs or CBTC System Performance Requirements stated in this Agreement); (2) City's use or combination of the CBTC System with products or data of the type for which the CBTC System was neither designed nor intended (which exclusion of obligation shall not include integration of the CBTC System with the SFMTA's Third-Party Systems identified in Contract Specifications, Section 28.3 (CBTC External Interfaces) ; or (3) the modification of the CBTC System in a manner not permitted under this Agreement or (where the Agreement is silent) without Contractor's prior written consent.

ARTICLE 7 LIABILITY OF THE PARTIES

7.1. City's Liability. City's payment obligations under this Agreement shall be limited to the payment of the compensation provided for in Article 4 of this Agreement. Notwithstanding any other provision of this Agreement, in no event shall City be liable, regardless of whether any claim is based on contract or tort, for any special, consequential, indirect or incidental damages, including, but not limited to, lost profits, arising out of or in connection with this Agreement or the Contractor's performance of the Services.

7.2. Contractor's Liability. Contractor's aggregate liability to the City is limited to the following: (a) during the Procurement Term, the total System Procurement Price in Table 1 of Appendix B1; and (b) during the Support Term, the total of sixty times the Adjusted Monthly Support Fee in Row 1, Column B of Table 3 of Appendix B1, as those amounts may be modified by Contract Modifications approved in accordance with Section 12.5 (Contract Modifications and Change Orders) or the City's exercise of Options listed in Table 2 of Appendix B. Said limitations of liability shall not apply to: (1) damages and other liability caused by Contractor's willful, intentional acts or omissions; (2) liability arising under or for violation of any applicable statute, City ordinance, regulation, or other laws; (3) damages and other liability arising under claims by third parties in accordance with Section 6.2. Indemnification; and (4) damages and other liability for infringement of any intellectual property right.

For greater certainty, the limitations of liability under this Section 7.2 shall not affect Contractor's obligations to maintain in full force and effect the insurance with the minimum coverages as detailed in Section 6.1., Insurance.

7.3. Limitations on Liability for Incidental and Consequential Damages and for Damages Related to Non-Vital Functions. Except for liquidated damages, Contractor shall not be responsible for indirect, incidental and consequential damages resulting from Contractor's acts or omissions, including, but not limited to, lost profits and business interruption. Except to the extent caused by Contractor's negligence or fault in the performance of this Agreement, Contractor shall not be responsible for damages related to functions specified as non-vital under Sections 16, 18, and 19 of the Technical Specifications (Appendix A). Nothing in this Agreement shall constitute a waiver or limitation of any rights that City may have under applicable law.

7.4. Joint and Several Liability. If Contractor is a joint venture partnership, the liability of each partner of the joint venture under this Agreement, including the obligations and requirements of this Article, shall be joint and several. No provision of any joint venture or similar agreement shall limit or amend this requirement.

7.5. Liability for Use of Equipment. City shall not be responsible for any damage to persons or property as a result of the use, misuse or failure of any equipment or tools provided by

and used by Contractor, or by any of its employees, for the purposes of performing any Work hereunder.

7.6. Liability for Reference Materials. Contractor acknowledges that the City has provided Contractor with the documents and other written descriptions, drawings, and other materials listed in Appendix L (Reference Materials) to this Agreement, which is information that the City has provided Contractor concerning existing City infrastructure, SFMTA systems, SFMTA transit operations, and other relevant information that Contractor may find useful in order to plan, design, implement and otherwise perform the Services. The City has provided the Reference Materials to Contractor as background and context to the Project only. The City does not warrant or in any way represent that the Reference Materials are complete or fully accurate. Contractor shall confirm all information and materials on which is relies to plan, design and implement the CBTC System. The City shall not be liable for Contractor's use or reliance on the Reference Materials. Contractor shall independently confirm the completeness and accuracy of any information that the Reference Materials contain.

ARTICLE 8 PAYMENT OF TAXES

8.1. Contractor to Pay All Taxes. Except for any applicable California sales and use taxes charged by Contractor to City, Contractor shall pay all taxes, including possessory interest taxes levied upon or as a result of this Agreement or the Services delivered pursuant hereto. Contractor shall remit to the State of California any sales or use taxes paid by City to Contractor under this Agreement. Contractor agrees to promptly provide information requested by the City to verify Contractor's compliance with any State requirements for reporting sales and use tax paid by City under this Agreement.

8.2. Possessory Interest Taxes. Contractor acknowledges that this Agreement may create a "possessory interest" for property tax purposes. Generally, such a possessory interest is not created unless the Agreement entitles Contractor to possession, occupancy, or use of City property for private gain. If such a possessory interest is created, then the following shall apply:

8.2.1. Contractor, on behalf of itself and any permitted successors and assigns, recognizes and understands that Contractor, and any permitted successors and assigns, may be subject to real property tax assessments on the possessory interest.

8.2.2. Contractor, on behalf of itself and any permitted successors and assigns, recognizes and understands that the creation, extension, renewal, or assignment of this Agreement may result in a "change in ownership" for purposes of real property taxes, and therefore may result in a revaluation of any possessory interest created by this Agreement. Contractor accordingly agrees on behalf of itself and its permitted successors and assigns to report on behalf of the City to the County Assessor the information required by Revenue and Taxation Code Section 480.5, as amended from time to time, and any successor provision.

8.2.3. Contractor, on behalf of itself and any permitted successors and assigns, recognizes and understands that other events also may cause a change of ownership of the possessory interest and result in the revaluation of the possessory interest. (see, e.g., Rev. & Tax. Code Section 64, as amended from time to time). Contractor accordingly agrees on behalf of itself and its permitted successors and assigns to report any change in ownership to the County Assessor, the State Board of Equalization or other public agency as required by law.

8.2.4. Contractor further agrees to provide such other information as may be requested by the City to enable the City to comply with any reporting requirements for possessory interests that are imposed by applicable law.

8.3. Withholding. Contractor agrees that it is obligated to pay all amounts due to the City under the San Francisco Business and Tax Regulations Code (SFBTRC) during the Contract Term. Pursuant to SFBTRC Section 6.10-2, Contractor further acknowledges and agrees that City may withhold any payments due to Contractor under this Agreement if Contractor is

delinquent in the payment of any amount required to be paid to the City under the SFBTRC. Any payments withheld under this paragraph shall be released to Contractor, without interest, upon Contractor curing its noncompliance with the SFBTRC requirements.

ARTICLE 9 TERMINATION AND DEFAULT

9.1. Termination for Convenience

9.1.1. Exercise of Option. City may, in its sole discretion, terminate this Agreement, at any time during the term hereof, for convenience and without cause. City shall exercise this Option by giving Contractor written notice of termination. The notice shall specify the date on which termination shall become effective.

9.1.2. Contractor Actions. Upon receipt of the notice of termination, Contractor shall commence and perform, with diligence, all actions necessary on the part of Contractor to effect the termination of this Agreement on the date specified by City and to minimize the liability of Contractor and City to third parties as a result of the termination. All such actions shall be subject to the prior approval of City. Such actions may include any or all of the following, without limitation:

(a) Halting the performance of all Services under this Agreement on the date(s) and in the manner specified by the SFMTA.

(b) Terminating all existing orders and subcontracts, and not placing any further orders or subcontracts for Materials, Services, Equipment or other items.

(c) At the SFMTA's direction, assigning to City any or all of Contractor's right, title, and interest under the orders and subcontracts terminated. Upon such assignment, the SFMTA shall have the right, in its sole discretion, to settle or pay any or all claims arising out of the termination of such orders and subcontracts.

(d) Subject to the SFMTA's approval, settling all outstanding liabilities and all claims arising out of the termination of orders and subcontracts.

(e) Completing performance of any Services that the SFMTA designates to be completed prior to the date of termination specified by the SFMTA.

(f) Taking such action as may be necessary, or as the SFMTA may direct, for the protection and preservation of any property related to this Agreement which is in the possession of Contractor and in which the SFMTA has or may acquire an interest.

(g) Delivering Materials, design documents, warranties, third-party Software and end-user licenses, CBTC System documentation, and Equipment to the SFMTA, and the SFMTA arranging to accept title to such items for which the City has compensated Contractor, or, at SFMTA's request, purchasing all or the portion of such items for which the SFMTA has not compensated Contractor as stated in Appendix B (Schedule of Prices and Calculation of Charges) or (if not price is stated) in accordance with the pricing requirements of Section 9.1.3 (Contractor Invoice). These provisions cover all warranty and maintenance spare parts, tools and equipment which may be stored by Contractor. The Contractor shall not sell, retain or dispose of all or a portion of any such items subsequent to receiving a notice of termination without the SFMTA's written directive and authorization.

(h) Providing complete documentation for all Materials delivered to SFMTA under this Agreement. The Contractor shall transfer all necessary licenses and warranties for the Materials and Software provided to SFMTA.

9.1.3. Contractor Invoice. Within 30 Days after the specified termination date, Contractor shall submit to the SFMTA an invoice, which shall set forth each of the following as a separate line item:

(a) The reasonable cost to Contractor, without profit, for all Work performed prior to the specified termination date, for which Work the SFMTA has not already tendered payment. Reasonable costs may include a reasonable allowance for actual overhead, not to exceed a total of 10% of Contractor's direct costs for said Work. Any overhead allowance shall be separately itemized. Contractor may also recover the reasonable cost of preparing the invoice.

(b) A reasonable allowance for profit on the cost of the Work described in the immediately preceding subsection (a), provided that Contractor can establish, to the satisfaction of the SFMTA, that Contractor would have made a profit had all Work under this Agreement been completed, and provided further, that the profit allowed shall in no event exceed 5% of such cost.

(c) The reasonable cost to Contractor of handling Materials returned to the vendor, delivered to the SFMTA or otherwise disposed of as directed by the SFMTA.

(d) A deduction for the cost of Materials which Contractor will retain and for which Contractor has been paid, amounts realized from the sale of Materials and not otherwise recovered by or credited to the SFMTA, and any other appropriate credits to the SFMTA against the cost of said Materials or other elements of the Work.

(e) The reasonable cost of the portion of the Materials Contractor for which the SFMTA has not paid Contractor, but that the SFMTA wants to acquire.

9.1.4. Nonrecoverable Costs. In no event shall the City be liable for costs incurred by Contractor (or any of its Affiliates, subcontractors or suppliers) after the termination date specified by the SFMTA, except for those costs specifically listed in Section 9.1.3 (Contractor Invoice). Such non-recoverable costs include, but are not limited to, anticipated profits on the Services under this Agreement, post-termination employee salaries, post-termination administrative expenses, post-termination overhead or unabsorbed overhead, attorneys' fees or other costs relating to a claim or lawsuit, prejudgment interest, or any other expense which is not reasonable or authorized under Section 9.1.3.

9.1.5. Deductions. In arriving at the amount due to Contractor under this Section, the SFMTA may deduct: (i) all payments previously made by the SFMTA for Services covered by Contractor's final invoice; (ii) any claim which the SFMTA may have against Contractor in connection with this Agreement; (iii) any invoiced costs or expenses excluded pursuant to the immediately preceding Section 9.1.4 (Nonrecoverable Costs); and (iv) in instances in which, in the opinion of the SFMTA, the cost of any portion of the Work performed under this Agreement is excessively high due to costs incurred to remedy or replace defective or rejected Services, the difference between the invoiced amount and the SFMTA's estimate of the reasonable cost of performing the invoiced Work in compliance with the requirements of this Agreement.

9.1.6. Payment Obligation. The City's payment obligation under this Section shall survive termination of this Agreement.

9.2. Termination for Default; Remedies

9.2.1. Event of Default. Each of the following shall constitute an immediate event of default (Event of Default) under this Agreement:

(a) Contractor fails or refuses to perform or observe any term, covenant or condition contained in any of the following Sections of this Agreement:

4.7	Submitting False Claims
5.12	Assignment
5.19	Bond Requirements
Article 6	Insurance and Indemnity

Article 8	Payment of Taxes
11.9	Alcohol and Drug-Free Workplace
12.12	Compliance with Laws
Article 13	Data and Security

(b) Contractor fails or refuses to perform or observe any other term, covenant or condition contained in this Agreement, including any obligation imposed by ordinance or statute and incorporated by reference herein, and such default is not cured within 30 days after written notice thereof from the SFMTA to Contractor. If Contractor defaults a second time in the same manner as a prior default cured by Contractor, the SFMTA may in its sole discretion immediately terminate the Agreement for default or grant an additional period not to exceed 30 days for Contractor to cure the default.

(c) Contractor (i) is generally not paying its debts as they become due; (ii) files, or consents by answer or otherwise to the filing against it of a petition for relief or reorganization or arrangement or any other petition in bankruptcy or for liquidation or to take advantage of any bankruptcy, insolvency or other debtors' relief law of any jurisdiction; (iii) makes an assignment for the benefit of its creditors; (iv) consents to the appointment of a custodian, receiver, trustee or other officer with similar powers of Contractor or of any substantial part of Contractor's property; or (v) takes action for the purpose of any of the foregoing.

(d) A court or government authority enters an order (i) appointing a custodian, receiver, trustee or other officer with similar powers with respect to Contractor or with respect to any substantial part of Contractor's property, (ii) constituting an order for relief or approving a petition for relief or reorganization or arrangement or any other petition in bankruptcy or for liquidation or to take advantage of any bankruptcy, insolvency or other debtors' relief law of any jurisdiction or (iii) ordering the dissolution, winding-up or liquidation of Contractor.

9.2.2. City's Remedies. On and after any Event of Default, City shall have the right to exercise its legal and equitable remedies, including, without limitation, the right to: terminate this Agreement; seek specific performance from the Contractor of all or any part of this Agreement; and exercise its rights pursuant to the Performance Bond and Guaranty. In addition, where applicable, City shall have the right (but no obligation) to cure (or cause to be cured) on behalf of Contractor any Event of Default after providing Surety and Contractor written notice and an opportunity to cure; if City proceeds after such reasonable notice to Surety and Contractor, it must mitigate costs and expenses as part of such cure. Contractor and its surety (sureties) and Guarantor(s) shall pay to City all reasonable and documented costs and expenses incurred by City in effecting such cure. City shall have the right to offset from any amounts due to Contractor under this Agreement: (i) all damages, losses, costs or expenses incurred by City as a result of an Event of Default; and (ii) any liquidated damages levied upon Contractor pursuant to the terms of this Agreement; and (iii), any damages imposed by any ordinance or statute that is incorporated into this Agreement by reference. This Section 9.2.2 (Remedies) shall survive termination of this Agreement. The SFMTA may withhold all or any portion of further payments to Contractor until such time that the SFMTA can determine the remaining amount owed to Contractor. The City's termination of this Agreement for Contractor's default shall not void, terminate or otherwise compromise the City's perpetual rights under the Software License. (See Section 10.3 and Appendix K.)

9.2.3. Remedies Are Not Exclusive. Except as expressly stated in this Agreement, all remedies provided for in this Agreement may be exercised individually or in combination with any other remedy available hereunder or under applicable laws, rules and regulations. The exercise of any remedy shall not preclude or in any way be deemed to waive

any other remedy. Nothing in this Agreement shall constitute a waiver or limitation of any rights that City may have under applicable law.

9.2.4. Adverse Court Decision. If a court determines that a termination for default is unlawful, the termination shall be deemed a termination for convenience.

9.2.5. Notice of Default. Any notice of default must be sent to the address set forth in Section 12.1 (Notices to the Parties).

9.3. No Waiver of Rights. The omission by either Party at any time to enforce any default or right reserved to it, or to require performance of any of the terms, covenants, or provisions hereof by the other Party at the time designated, shall not constitute a waiver of any such default or right to which the Party is entitled, nor shall it in any way affect the right of the Party to enforce such provisions thereafter.

9.4. Rights and Duties upon Termination or Expiration

9.4.1. Survival. This Section 9.4.1 and the following Sections of this Agreement listed below, shall survive termination or expiration of this Agreement:

4.5.2	City's Payment Obligations
4.5.10	Grant-Funded Contracts
4.6	Audit and Inspection of Records
4.7	Submitting False Claims
5.11	Independent Contractor; Payment of Employment Taxes and Other Expenses
Article 6	Insurance and Indemnity
Article 7	Liability of the Parties
Article 8	Payment of Taxes
9.1.6	Payment Obligation
9.3	No Waiver of Rights
10.1	Ownership of Results
10.2	Works for Hire
10.3	Software License
12.8	Dispute Resolution Procedures
12.9	Agreement Made in California; Venue
12.10	Construction and Interpretation of Contract Documents
12.11	Entire Agreement
12.12	Compliance with Laws
12.13	Severability
Article 13	Data and Security

9.4.2. Contractor Duties. Subject to the survival of the Sections identified in Section 9.4.1 (Survival) above, if this Agreement is terminated prior to expiration of the Contract Term specified in Article 3 (Contract Term), this Agreement shall be of no further force or effect. Contractor shall transfer title to City, and deliver in the manner, at the times, and to the extent, if any, directed by City, any Work in progress, completed Work, supplies, equipment, Materials and other items procured, acquired or produced as a part of or in connection with the performance of this Agreement, and any completed or partially completed Work which, if this Agreement had been completed, Contractor would have been required to provide to City.

ARTICLE 10 RIGHTS IN DELIVERABLES; SOFTWARE LICENSE

10.1. Ownership of Results. Any interest of Contractor, its Affiliates or its subcontractors in the Deliverables, including any drawings, plans, specifications, blueprints,

studies, reports, memoranda, computation sheets, computer files and media or other documents created or prepared by Contractor, its Affiliates, or its subcontractors for the purposes of this Agreement and solely for the use of the SFMTA, shall become the property of and will be transmitted to City, except for Contractor's Technology, which is defined as any Deliverables, technology or intellectual property of Contractor, its Affiliates or Subcontractors that were developed before or separately from the Agreement. The City shall be granted a non-exclusive perpetual license to use Contractor's Technology included in Deliverables pursuant to 10.1.1. However, unless expressly prohibited elsewhere in this Agreement, Contractor shall be granted a perpetual license to use said Deliverables for which it does not retain ownership, including the right to retain and use copies for reference and as documentation of its experience and capabilities. The Deliverables that are City property under this Section 10.1 do not include Software, systems operations and maintenance manuals or other materials described in Section 10.3 (Software License), which Contractor shall license to the City for its use as provided in the Software License. City Data is the property of the City. Contractor may access and utilize City Data only to the extent necessary to implement, operate and maintain the System. In the event of uncertainty with respect to the ownership of any Deliverable, the Parties agree to discuss in good faith to determine the corresponding ownership.

10.2. Works for Hire. If, in the performance of the Services, Contractor, its Affiliates, or its subcontractors creates Deliverables solely for use of the City pursuant to this Agreement, namely artwork, copy, posters, billboards, photographs, videotapes, audiotapes, reports, diagrams, surveys, blueprints, or any other original works of authorship, whether in digital or any other format, except for Contractor's Technology, such works of authorship shall be works for hire as defined under Title 17 of the United States Code, and all copyrights in such works shall be the property of the City. If any Deliverables created by Contractor, its Affiliate(s), or its subcontractor(s) solely for use of the City under this Agreement are ever determined not to be works for hire under U.S. law, Contractor hereby assigns all Contractor's copyrights to such Deliverables to the City, agrees to provide any material and execute any documents necessary to effectuate such assignment, and agrees to include a clause in every subcontract imposing the same duties upon subcontractor(s). For greater certainty, delivery of Contractor's Technology will not result in the transfer of ownership in any of the concerned Deliverables. With City's prior written approval, Contractor, its Affiliate(s), and its subcontractor(s) may retain and use copies of such works for reference and as documentation of their respective experience and capabilities. If any of the foregoing Deliverables are Contractor's Technology or Contractor's Proprietary Information, the City shall have a perpetual, unlimited license to use said Contractor's Technology or Proprietary Information for the operation and maintenance of the System. Contractor's Technology and Materials described in Section 10.3 (Software License), including Software, source code, and operations and maintenance manuals are not Works for Hire as described in this Section 10.2.

10.3. Software License

10.3.1. As more specifically provided in the Software License in Appendix K (CBTC Software License Agreement), Contractor grants to the City a non-exclusive, non-transferable, perpetual license to use the Software purchased under this Agreement, including all Software procured by Contractor and provided to City from third parties, from the date of full payment for the Software. The license for the Software shall be limited to the SFMTA's use for its operation and maintenance of the CBTC System. The City has no right to grant sublicenses. Contractor warrants that it has the title to and/or authority to grant said license(s) and sublicenses(s) to the City. The City receives no title or ownership rights to Software purchased under this Agreement, and all such rights shall remain with Contractor or its suppliers.

10.3.2. The City agrees that the Software provided to it by Contractor under this Agreement, and any Enhancements, Updates, Upgrades, renewals, extensions, or expansions of the Software, shall, as between the Parties, be treated as proprietary and a trade secret of

Contractor or its suppliers and be subject to the provisions of Section 13.1 (Nondisclosure of Proprietary, Private, or Confidential Information).

10.3.3. The Software provided under this Agreement may contain software obtained by Contractor from a third-party source. Any license fee that Contractor has paid for the inclusion of any such third-party software in the System is included in the compensation paid by City to Contractor under this Agreement for the Contract Term only. After the Contract Term, any third party licenses and fees shall be the responsibility of the City. Any such third-party software is also included in Contractor's warranties and support Services under this Agreement. Contractor agrees to place all such third-party warranties and service agreements in the City's name as the software and system owner or authorized end-user. The City agrees to abide by the relevant terms and conditions or End User License Agreements ("EULA's") of any third-party software. City and Contractor acknowledge and agree that as part of the Warranty and/or Support services provided by Contractor in this Agreement, Contractor will manage all third-party warranties on City's behalf and the City shall resolve all issues with the third-party software directly with Contractor. The City will only directly purchase third-party software that is identified in Appendix A (Contract Specifications) Section 9.3 (Permanent SFMTA Furnished Items). For directly purchased software, the City will manage the third-party warranties and resolve all issues with the third-party software directly with the third-party software provider.

10.3.4. This Section 10.3 and Appendix K (CBTC Software License Agreement) shall survive expiration or termination of this Agreement.

ARTICLE 11 ADDITIONAL REQUIREMENTS INCORPORATED BY REFERENCE

11.1. Laws Incorporated by Reference. The full text of the laws listed in this Article 11 (Additional Requirements Incorporated by Reference), including enforcement and penalty provisions, are incorporated by reference into this Agreement. The full text of the San Francisco Municipal Code provisions incorporated by reference in this Article and elsewhere in the Agreement (Mandatory City Requirements) are available at http://www.amlegal.com/codes/client/san-francisco_ca.

11.2. Conflict of Interest. By executing this Agreement, Contractor certifies that it does not know of any fact which constitutes a violation of Section 15.103 of the City's Charter; Article III, Chapter 2 of City's Campaign and Governmental Conduct Code; Title 9, Chapter 7 of the California Government Code (Section 87100 et seq.), or Title 1, Division 4, Chapter 1, Article 4 of the California Government Code (Section 1090 et seq.), and further agrees promptly to notify the City if it becomes aware of any such fact during the Contract Term.

11.3. Prohibition on Use of Public Funds for Political Activity. In performing the Services, Contractor shall comply with San Francisco Administrative Code Chapter 12G, which prohibits funds appropriated by the City for this Agreement from being expended to participate in, support, or attempt to influence any political campaign for a candidate or for a ballot measure. Contractor is subject to the enforcement and penalty provisions in Chapter 12G.

11.4. Consideration of Salary History. Contractor shall comply with San Francisco Administrative Code Chapter 12K, the Consideration of Salary History Ordinance or "Pay Parity Act." Contractor is prohibited from considering current or past salary of an applicant in determining whether to hire the applicant or what salary to offer the applicant to the extent that such applicant is applying for employment to be performed on this Agreement or in furtherance of this Agreement, and whose application, in whole or part, will be solicited, received, processed or considered, whether or not through an interview, in the City or on City property. The ordinance also prohibits employers from (a) asking such applicants about their current or past salary or (b) disclosing a current or former employee's salary history without that employee's authorization unless the salary history is publicly available. Contractor is subject to the enforcement and penalty provisions in Chapter 12K. Information about and the text of Chapter 12K is available on the web at https://sfgov.org/olse/consideration-salary-history. Contractor is

required to comply with all of the applicable provisions of 12K, irrespective of the listing of obligations in this Section.

11.5. Nondiscrimination Requirements

11.5.1. Nondiscrimination in Contracts. Contractor shall comply with the provisions of Chapters 12B and 12C of the San Francisco Administrative Code. Contractor shall incorporate by reference in all subcontracts the provisions of Sections 12B.2(a), 12B.2(c)-(k), and 12C.3 of the San Francisco Administrative Code and shall require all Affiliates and Subcontractors to comply with such provisions. Contractor is subject to the enforcement and penalty provisions in Chapters 12B and 12C.

11.5.2. Nondiscrimination in the Provision of Employee Benefits. Contractor shall comply with San Francisco Administrative Code 12B.2. Contractor shall not as of the date of this Agreement, and will not during the Contract Term, in any of its operations in San Francisco, on real property owned by San Francisco, or where work is being performed for the City elsewhere in the United States, discriminate in the provision of employee benefits between employees with domestic partners and employees with spouses and/or between the domestic partners and spouses of such employees, subject to the conditions set forth in San Francisco Administrative Code Section 12B.2.

11.6. Small Business Enterprise Program

11.6.1. General. The SFMTA is committed to a Small Business Enterprise Program (SBE Program) for the participation of SBEs in contracting opportunities. In addition, Contractor must comply with all applicable federal regulations regarding Small Business Enterprise (SBE) participation, as set out in Title 49, Part 26 of the Code of Federal Regulations, with respect to SBEs performing Work under this Agreement. More information on federal SBE requirements can be found on the internet at: http://www.fta.dot.gov/civilrights/12326.html.

11.6.2. Compliance with SBE Program. Contractor shall comply with the SBE provisions contained in Appendix H attached to this Agreement and incorporated by reference as though fully set forth, including, but not limited to, achieving and maintaining the SBE goal set for the total dollar amount Awarded for the services to be performed under this Agreement. Failure of Contractor to comply with any of these requirements shall be deemed a material breach of this Agreement.

11.6.3. Nondiscrimination in Hiring. Pursuant to City and SFMTA policy, Contractor is encouraged to recruit actively minorities and women for its workforce and take other steps within the law, such as on-the-job training and education, to ensure non-discrimination in Contractor's employment practices.

11.7. Minimum Compensation Ordinance. The City urges Contractor to pay employees performing the Services no less than the minimum compensation required by San Francisco Administrative Code Chapter 12P, including a minimum hourly gross compensation, compensated time off, and uncompensated time off. Information about and the text of the Chapter 12P is available on the web at http://sfgov.org/olse/mco.

11.8. First Source Hiring Program. Contractor must comply with all of the provisions of the First Source Hiring Program, Chapter 83 of the San Francisco Administrative Code, that apply to this Agreement, and Contractor is subject to the enforcement and penalty provisions in Chapter 83.

11.9. Alcohol and Drug-Free Workplace. City reserves the right to deny access to or to require Contractor to remove from City facilities personnel of any Contractor, Affiliate, or Subcontractor who City has reasonable grounds to believe has engaged in alcohol abuse or illegal drug activity which in any way impairs City's ability to maintain safe work facilities or to protect the health and well-being of City employees and the general public. City shall have the right of final approval for the entry or re-entry of any such person previously denied access to, or

removed from, City facilities. Illegal drug activity means possessing, furnishing, selling, offering, purchasing, using or being under the influence of illegal drugs or other controlled substances for which the individual lacks a valid prescription. Alcohol abuse means possessing, furnishing, selling, offering, or using alcoholic beverages, or being under the influence of alcohol.

Contractor agrees in the performance of this Agreement to maintain a drug-free workplace by notifying employees that unlawful drug use is prohibited and specifying what actions will be taken against employees for violations; establishing an on-going drug-free awareness program that includes employee notification and, as appropriate, rehabilitation. Contractor can comply with this requirement by implementing a drug-free workplace program that complies with the Federal Drug-Free Workplace Act of 1988 (41 U.S.C. § 701).

11.10. Limitations on Contributions. By executing this Agreement, Contractor acknowledges its obligations under Section 1.126 of the City's Campaign and Governmental Conduct Code, which prohibits any person who contracts with, or is seeking a contract with, any department of the City for the rendition of personal services, for the furnishing of any material, supplies or equipment, for the sale or lease of any land or building, for a grant, loan or loan guarantee, or for a development agreement, from making any campaign contribution to (a) a City elected official if the contract must be approved by that official, a board on which that official serves, or the board of a state agency on which an appointee of that official serves, (b) a candidate for that City elective office, or (c) a committee controlled by such elected official or a candidate for that office, at any time from the submission of a Proposal for the contract until the later of either the termination of negotiations for such contract or twelve months after the date the City approves the contract. The prohibition on contributions applies to each prospective party to the contract; each member of Contractor's board of directors; Contractor's chairperson, chief executive officer, chief financial officer and chief operating officer; any person with an ownership interest of more than 10% in Contractor; any Affiliate or Subcontractor listed in the bid or contract; and any committee that is sponsored or controlled by Contractor. Contractor certifies that it has informed each such person of the limitation on contributions imposed by Section 1.126 by the time it submitted a Proposal for the contract and has provided the names of the persons required to be informed to the City department with whom it is contracting.

11.11. Consideration of Criminal History in Hiring and Employment Decisions. City urges Contractor to comply with the provisions of Chapter 12T (City Contractor/Subcontractor Consideration of Criminal History in Hiring and Employment Decisions) of the San Francisco Administrative Code (Chapter 12T), including the remedies provided, and implementing regulations, as may be amended from time to time. The provisions of Chapter 12T are incorporated by reference and made a part of this Agreement as though fully set forth herein. The text of the Chapter 12T is available on the web at http://sfgov.org/olse/fco. Contractor is required to comply with all of the applicable provisions of 12T, irrespective of the listing of obligations in this Section. Capitalized terms used in this Section and not defined in this Agreement shall have the meanings assigned to such terms in Chapter 12T.

The requirements of Chapter 12T shall only apply to: (1) Contractor's, Affiliates', or Subcontractors' operations to the extent those operations are in furtherance of the performance of this Agreement; (2) applicants and employees who would be or are performing Work in furtherance of this Agreement; and (3) shall apply when the physical location of the employment or prospective employment of an individual is wholly or substantially within San Francisco. Chapter 12T shall not apply when the application in a particular context would conflict with federal or state law or with a requirement of a government agency implementing federal or state law.

11.12. Food Service Waste Reduction Requirements. City urges Contractor to comply with the Food Service Waste Reduction Ordinance, as set forth in San Francisco Environment Code Chapter 16, including but not limited to the remedies for noncompliance provided therein.

11.13. Tropical Hardwood and Virgin Redwood Ban. The City urges Contractor not to import, purchase, obtain, or use for any purpose, any tropical hardwood, tropical hardwood wood product, virgin redwood or virgin redwood wood product, in accordance with San Francisco Environment Code Section 804(b).

ARTICLE 12 GENERAL REQUIREMENTS

12.1. Notices to the Parties. Unless otherwise indicated in this Agreement, all written communications sent by the Parties may be sent by U.S. mail or e-mail, and shall be addressed as follows:

To City: San Francisco Municipal Transportation Agency
1455 Market Street, 7th floor
San Francisco, CA 94103
Attn: Dan Howard
dan.howard@sfmta.com

To Contractor:
[Enter Contractor Information]

All notices between the parties required by this Agreement or by law, and any communications concerning breach, default, or other communication concerning failure to comply with a material requirement of the Agreement shall also be sent to:

To City: San Francisco Municipal Transportation Agency
Muni Metro East Facility
601 25th Street,
San Francisco, CA 94107
Attn: Janet Gallegos
janet.gallegos@sfmta.com

and Director of Transit
San Francisco Municipal Transportation Agency
1 South Van Ness, 7th floor
San Francisco, CA 94103

To Contractor:

[Enter Contractor Information]

Any notice of default or breach of contract must be sent by US Mail first class with email confirmation, or by overnight delivery service or courier, with a signature obtained at delivery. Either Party may change the address to which notice is to be sent by giving written notice thereof to the other Party. If email notification is used, the sender must specify a receipt notice.

12.2. Compliance with Americans with Disabilities Act. Contractor shall provide the Services in a manner that complies with the Americans with Disabilities Act (ADA), including but not limited to Title II program access requirements, and all other applicable federal, state and local disability rights legislation.

12.3. Incorporation of Recitals. The Recitals stated at the beginning of these General Provisions are incorporated into and made part of the Agreement.

12.4. Sunshine Ordinance. Contractor acknowledges that this Agreement and all records related to its formation, Contractor's performance of Services, and City's payment are subject to the California Public Records Act, (California Government Code §6250 et. Seq.), and the San Francisco Sunshine Ordinance, (San Francisco Administrative Code Chapter 67). Such records are subject to public inspection and copying unless exempt from disclosure under federal, California or local law.

12.5. Contract Modifications and Change Orders

12.5.1. Contract Modifications. Either the SFMTA or the Contractor can request a Contract Modification to change the Work within the general scope of the Contract in a way that requires an increase in the Contract Amount and/or an extension of the Contract Term. Appendix E, Contract Changes, establishes the procedure to be followed by the Parties to request to modify the Contract. This Agreement may not be modified, nor may compliance with any of its terms be waived (except as noted in Section 12.1 (Notices to the Parties) regarding change in contract personnel or place of notice) unless such Contract Modification be effected by written instrument executed and approved in accordance with Appendix E, and as required by this Agreement, City law, and the policies of the SFMTA Board of Directors.

12.5.2. Change Orders. The SFMTA shall have the authority, without the execution of a formal Contract Modification, to issue Change Orders to modify the Work within the general scope of the Contract, provided that such Change Orders do not require or involve an increase in the Contract Amount or extension of the Contract Term. Contractor shall not proceed with any Work contemplated in any Change Order until it receives written notification to commence such Work from SFMTA. All Change Orders must be approved by the SFMTA's Project Manager in a reasonable written determination. If Contractor asserts that the proposed Change Order does require an increase in the Contract Amount and/or an extension of the Contract Term, the Contractor is required to submit a Request for Contract Change in accordance with Appendix E. All Change Orders will be incorporated to the Agreement, after written execution by the Parties, and will be memorialized in the next Contract Modification.

12.5.3. Procedures. All Contract Modifications and Change Orders are subject to the approval procedures and requirements set out in this Section 12.5 and Appendix E (Contract Changes).

12.5.4. CCO Approval. Contractor shall cooperate with the SFMTA to submit to the CCO for approval any Contract Modification that would result in a cumulative increase of the original Contract Amount by more than 20 percent.

12.6. Contract Claim Requirements. The requirements that must be met before the Contractor can submit a claim to the SFMTA are set out in Appendix E (Contract Changes). After meeting those requirements, Contractor shall not be entitled to additional compensation or change in Contract Time unless Contractor has submitted a written claim to the SFMTA Project Manager within 30 days of the completion of the procedures of Appendix E. Contractor must provide supporting documentation and reference to applicable Contract provisions in its claim. Contractor's failure to submit a written claim as required in this Agreement may be treated as a waiver of the claim, and shall render void any subsequent claim under Government Code section 900, et seq.

12.7. Authority of Project Manager. The SFMTA Project Manager shall prepare a reasonable and timely determination in writing of all issues and disputes that arise under the Contract. For claims, this determination shall be issued no more than 30 days from the date of the corresponding notification from the Contractor. Contractor may appeal the Project Manager's decision to the Director of Transit, following Section 12.8 (Dispute Resolution Procedures), below.

12.8. Dispute Resolution Procedures

12.8.1. Negotiation; Determination. The Parties will attempt in good faith to negotiate resolution of any dispute relating to this Agreement. Disputes that are not resolved by negotiation shall be decided in writing by the SFMTA Project Manager. See Section 12.7 (Authority of Contract Manager). The Project Manager's decision shall be final, unless within ten Days from the date of such decision, Contractor submits a written appeal of the decision with supporting documentation to the Director of Transit or his/her designee. After the appeal is submitted and before the Director of Transit issues a written decision, either Party may require, by written notice to the other, that a mutually acceptable third-party mediator be selected for the purpose of facilitating a negotiated resolution of the dispute. The Parties will share the costs of the mediation equally. If the mediation is unsuccessful, the subsequent decision of the Director of Transit shall be administratively final for the purposes of Section 12.8.5, Government Code Claim Requirement.

12.8.2. No Slowing or Suspension of Work. The status of any dispute notwithstanding, Contractor shall not suspend or slow its performance of the Work pending resolution of any dispute, and Contractor shall proceed diligently with the performance of its obligations under this Agreement in accordance with the requirements stated in this Agreement and the written directions of the City except as indicated in Section 4.5.6.1 Payment Terms and in Appendix E, Section 7.2, Unilateral Contract Modification. Whenever a payment amount is in dispute, the City shall pay the amount not in dispute subject to all other applicable provisions, requirements and limitations set forth in this Agreement.

12.8.3. Alternative Dispute Resolution. If the Parties agree in writing, a dispute may be resolved by an agreed alternative dispute resolution process.

12.8.4. Prevailing Party Does Not Recover Fees or Costs. Neither Party shall recover from the other Party its administrative costs, attorneys' fees, expert costs, or other costs incurred in the course of negotiating, mediating or litigating any dispute arising from or related to this Agreement; each Party shall bear its own fees and costs, and any rule or practice awarding a prevailing party its fees and costs shall not apply to this Agreement.

12.8.5. Government Code Claim Requirement. No suit for money or damages may be brought against the City until Contractor has exhausted: (a) its contract remedies, provided in Sections 12.6 (Contract Claim Requirements), 12.7 (Authority of Project Manager), and 12.8.1 (Negotiation; Determination); and (b) its administrative remedies by submitting a written claim to the City in accordance with the provisions of San Francisco Administrative Code Chapter 10 and California Government Code Section 900, et seq. Nothing stated in this Agreement shall operate to toll, waive or excuse Contractor's compliance with the California Government Code Claim requirements, as set forth in San Francisco Administrative Code Chapter 10 and California Government Code Section 900, et seq.

12.9. Agreement Made in California; Venue. This Agreement was advertised, negotiated, executed, and shall be performed in San Francisco, California. The City and County of San Francisco is a municipal corporation established under the constitution and laws of the State of California, which shall govern the formation, interpretation and performance of this Agreement. Venue for all litigation concerning this Agreement shall be in San Francisco, California, and Contractor waives all arguments contesting San Francisco as appropriate venue.

12.10. Construction and Interpretation of Contract Documents

12.10.1. Cooperative Drafting. This Agreement has been negotiated and drafted through a cooperative effort of City and Contractor, and both Parties have had an opportunity to have the Agreement reviewed and revised by legal counsel. No Party shall be considered the drafter of this Agreement, and no presumption or rule that an ambiguity shall be construed against the Party drafting of this Agreement or any part of it shall apply to the interpretation or enforcement of this Agreement or any part of it.

12.10.2. Contractor's Scope of Work. In case of any ambiguity in the Agreement, the Agreement shall be interpreted and constructed so that Contractor is the party responsible and obligated to perform all Work and Incidental Work, to provide all Services, and furnish all Equipment, Software, Deliverables, Submittals, tools and Materials necessary to design, implement, test and certify the CBTC System for Revenue Service in accordance with the Contract Specifications, unless and only to the extent that any provision of the Agreement expressly states that the SFMTA, another SFMTA contractor or another entity is obligated to perform a specific task or service or furnish materials.

12.10.3. Captions and Titles Are for Reference Only. All paragraph captions are for reference only and shall not be considered in construing this Agreement.

12.11. Entire Agreement. This Contract sets forth the entire agreement between the Parties. The Contract Documents constitute an integrated agreement, which supersedes all other oral or written understandings and provisions. All Included Appendices in Article 14 to this Agreement are incorporated by reference as though fully set forth. This Agreement may be modified only as provided in Section 12.5 (Contract Modifications and Change Orders).

12.12. Compliance with Laws. Contractor shall keep itself fully informed of the City's Charter, codes, ordinances and duly adopted rules and regulations of the City and of all state, and federal laws (collectively "Codes") that in any manner affect the Project and the performance of this Agreement, and Contractor shall at all times comply with such Codes as they may be amended from time to time. If any Code changes during the course of the Agreement which impacts the Contractor's delivery of the Works or cost thereof the Parties shall meet and discuss in good faith the possibility of reducing the impact of such change. Any claim for compensation shall be submitted and processed as a Contract Modification issued under Section 12.5.

12.13. Severability. Should the application of any provision of this Agreement to any particular facts or circumstances be found by a court of competent jurisdiction to be invalid or unenforceable, then (a) the validity of other provisions of this Agreement shall not be affected or impaired thereby, and (b) such provision shall be enforced to the maximum extent possible so as to effect the intent of the Parties and shall be reformed without further action by the Parties to the extent necessary to make such provision valid and enforceable.

12.14. Order of Precedence. Contractor agrees to perform the Services in accordance with the terms and conditions of this Agreement and the Contract Specifications. In case of any ambiguity or conflict in Contract requirements, the Contract shall be interpreted using the following order of Precedence:

1. Contract Modifications in inverse chronological order
2. Change Orders approved by the SFMTA in inverse chronological order
3. Contract Specifications (Appendix A to Agreement)
4. General Provisions
5. Included Appendices (other than Appendix A)

12.15. Time is of the Essence. Time is of the essence in Contractor's performance of the Services.

12.16. Federal Requirements. Contractor shall comply with all applicable federal contracting requirements, including but not limited to the Federal Contract Requirements set out in Appendix G to this Agreement, which are incorporated by reference as if fully set out here. If there is any conflict between any federal contracting requirement and any provision of this Agreement, the federal requirement shall prevail. The SFMTA has not adopted the contract requirements of the Federal Acquisition Regulations (FAR). As a department of the City and County of San Francisco, exercising its home rule authority granted by the California constitution, the SFMTA shall not be bound by any provision of the FAR.

12.17. Large Vehicle Driver Safety Training Requirements

12.17.1. Contractor agrees that before any of its employees, Affiliates, and subcontractors drive large vehicles within the City and County of San Francisco, those employees, Affiliates, and subcontractors shall successfully complete either (a) the SFMTA's Large Vehicle Urban Driving Safety training program or (b) a training program that meets the SFMTA's approved standards for large vehicle urban driving safety. The SFMTA's approved standards for large vehicle urban driving safety is available for download at www.SFMTA.com/largevehicletrainingstandards. This requirement does not apply to drivers providing delivery services who are not employees, Affiliates, or subcontractors of Contractor. For purposes of this section, "large vehicle" means any single vehicle or combination of vehicle and trailer with an unladen weight of 10,000 pounds or more, or a van designed to carry 10 or more people.

12.17.2. By entering into this Agreement, Contractor agrees that in the event Contractor fails to comply with the Large Vehicle Driver Safety Training Requirements, the City will suffer actual damages that will be impractical or extremely difficult to determine; further, Contractor agrees that the sum of up to One Thousand Dollars ($1,000) per employee, Affiliate, or subcontractor who is permitted to drive a large vehicle in violation of these requirements is not a penalty, but is a reasonable estimate of the loss that City will incur based on Contractor's failure to comply with this requirement, established in light of the circumstances existing at the time this Contract was Awarded. City may deduct a sum representing the liquidated damages from any money due to Contractor. Such deductions shall not be considered a penalty, but rather agreed monetary damages sustained by City because of Contractor's failure to comply.

12.18. MacBride Principles – Northern Ireland. The provisions of San Francisco Administrative Code §12F are incorporated herein by this reference and made part of this Agreement. By signing this Agreement, Contractor confirms that Contractor has read and understood that the City urges companies doing business in Northern Ireland to resolve employment inequities and to abide by the MacBride Principles and urges San Francisco companies to do business with corporations that abide by the MacBride Principles.

ARTICLE 13 DATA AND SECURITY

13.1. Nondisclosure of Private, Proprietary, or Confidential Information

13.1.1. Protection of Private Information. If this Agreement requires City to disclose "Private Information" to Contractor within the meaning of San Francisco Administrative Code Chapter 12M, Contractor, Contractor's Affiliates, and subcontractors shall use such information only in accordance with the restrictions stated in Chapter 12M and in this Agreement and only as necessary in performing the Services. Contractor is subject to the enforcement and penalty provisions in Chapter 12M.

13.1.2. Confidential and Proprietary Information. Contractor understands and agrees that the performance of the Work under this Agreement will involve access to Confidential Information. Contractor and any of its Affiliates, subcontractors or agents shall use Proprietary Information only in accordance with all applicable local, California and federal laws restricting the access, use and disclosure of Confidential Information, and only as necessary in the performance of this Agreement. Contractor shall exercise the same standard of care to protect such information as a reasonably prudent contractor would use to protect its own proprietary or Confidential Information. Contractor's failure to comply with any requirements of local, California or federal laws restricting access, use and disclosure of Confidential Information shall be deemed a material breach of this Agreement, for which City may terminate the Agreement. In addition to termination or any other remedies set forth in this Agreement or available in equity or law, the City may bring a false claim action against Contractor pursuant to Chapters 6 or 21 of the Administrative Code or debar Contractor. Contractor agrees to include all of the terms and conditions regarding Confidential Information contained in this Agreement in all subcontractor

or agency contracts providing services under this Agreement. The City acknowledges that in the course of designing and implementing the CBTC, the City will have access to Proprietary Information.

13.1.3. Obligation of Confidentiality. Subject to San Francisco Administrative Code Section 67.24(e), any applicable open records or freedom of information statutes, and any other applicable laws, Parties agree to hold all Confidential Information and Proprietary Information in strict confidence and not to copy, reproduce, sell, transfer, or otherwise dispose of, give or disclose such Confidential Information or Proprietary Information to third parties other than employees, agents, Affiliates, or authorized subcontractors of a Party who have a need to know in connection with this Agreement, or to use such Confidential Information or Proprietary Information for any purposes whatsoever other than the performance of this Agreement. If a Party determines that an employee, agent, Affiliate, or authorized subcontractor has a need to know in connection with this Agreement, the Party may disclose such Confidential Information or Proprietary Information under an agreement with protections equivalent to the Sensitive Security Information Confidentiality and Nondisclosure Agreement included in the Request for Proposals. The Parties agree to advise and require its respective employees, agents, Affiliates, and subcontractors of their obligations to keep all Confidential Information and Proprietary Information confidential.

13.1.4. Nondisclosure

(a) Contractor agrees and acknowledges that it shall have no proprietary interest in any Confidential Information of the City and will not disclose, communicate or publish the nature or content of such information to any person or entity, nor use, except in connection with the performance of its obligations under this Agreement or as otherwise authorized in writing by the City, any of the Confidential Information it produces, receives, acquires or obtains from the disclosing Party.

(b) Contractor shall take all necessary steps to ensure that the City's Confidential Information is securely maintained. Contractor's obligations set forth herein shall survive the termination or expiration of this Agreement.

(c) In the event Contractor becomes legally compelled to disclose any City Confidential Information, it shall provide the SFMTA with prompt notice thereof and shall not divulge any information until the SFMTA has had the opportunity to seek a protective order or other appropriate remedy to curtail such disclosure. If such actions by the SFMTA are unsuccessful, or the SFMTA otherwise waives its right to seek such remedies, Contractor shall disclose only that portion of the City's Confidential Information that it is legally required to disclose.

(d) The SFMTA shall take all necessary steps to ensure that Contractor's Proprietary Information is securely maintained. The SFMTA's obligations set forth herein shall survive the termination or expiration of this Agreement.

(e) The SFMTA shall agree not to disclose any Proprietary Information to any third party without the Contractor's prior consent, unless it becomes legally compelled to disclose any Contractor Proprietary Information, in which case it shall provide Contractor with prompt notice thereof and shall not divulge any Proprietary Information until Contractor has had the opportunity to seek a protective order or other appropriate remedy to curtail such disclosure. If such actions by the Contractor are unsuccessful, or Contractor otherwise waives its right to seek such remedies, the SFMTA shall disclose only that portion of the Contractor's Proprietary Information that it is legally required to disclose.

13.1.5. Cooperation to Prevent Disclosure of City's Confidential Information. Contractor shall use its best efforts to assist the SFMTA in identifying and preventing any unauthorized use or disclosure of any City's Confidential Information. Without limiting the foregoing, Contractor shall advise the City immediately in the event Contractor learns or has

reason to believe that any person who has had access to City's Confidential Information has violated or intends to violate the terms of this Agreement, and Contractor will cooperate with the SFMTA in seeking injunctive or other equitable relief against any such person.

13.1.6. Remedies for Breach of Obligation of Confidentiality. Contractor acknowledges that breach of its obligation of confidentiality may give rise to irreparable injury to the SFMTA, which damage may be inadequately compensable in the form of monetary damages. Accordingly, the SFMTA may seek and obtain injunctive relief against the breach or threatened breach of the foregoing undertakings, in addition to any other legal remedies that may be available, to include, at the sole election of the SFMTA, the immediate termination, without liability to the SFMTA or City, of this Agreement.

13.1.7. Surrender of City's Confidential Information upon Termination. Upon termination of this Agreement, including but not limited to expiration of the term, early termination or termination for convenience, Contractor shall, within five Days from the date of termination, return to the SFMTA any and all City's Confidential Information received from the SFMTA, or created or received by Contractor on behalf of the SFMTA, which are in Contractor's possession, custody, or control.

13.1.8. Sensitive Security Information (SSI)

(a) Sensitive Security Information (SSI) Documents

13.1.8.a.1 Certain documents issued to Contractor and created by the Contractor as part of the Work under the Contract are Sensitive Security Information ("SSI Documents") as that term is defined in Section 2.94 (Sensitive Security Information).

13.1.8.a.2 The SSI Documents are identified by the markings printed on individual documents, drawings and exterior covers of documents and drawing sets that indicate that they are SSI Documents. SSI Documents are City's Confidential Information.

13.1.8.a.3 Contractor shall recognize that access to any part of the SSI Documents by unauthorized persons or organizations would pose significant security risk to the Project and public safety.

(b) Use of the SSI Documents

13.1.8.b.1 The Contractor is required to sign and agree to the terms and conditions of a Sensitive Security Information Confidentiality and Nondisclosure Agreement (NDA) to be authorized to access and handle any SSI required to perform the Work under Contract for this Project. For any questions or instructions regarding the SSI Documents or the NDA, Contractor shall contact the SFMTA using the contact information in Section 12.1 (Notices to Parties).

13.1.8.b.2 Contractor shall use the SSI Documents only for the purposes of performing the Work, and for no other purpose. Any documents prepared by the Contractor during contract performance containing information from an SSI Document shall be marked as SSI in the manner required by applicable federal law and the terms of the NDA.

13.1.8.b.3 Contractor shall guard the SSI Documents safe and secure at all times from disclosure to unauthorized personnel and shall only allow access to the SSI Documents to persons with a "need to know" for performing the Work. When the SSI Documents are not being used to perform the Work, the Contractor shall limit access to the SSI Documents to a locked, secure area so that the SSI Documents are not physically or visually accessible to persons who are not directly involved in performing the Work. When unattended, physical copies or media containing the SSI Documents must be secured in a locked container, office, or other restricted access area with access to the keys or combination limited to those with a need to know.

13.1.8.b.4 Contractor shall not copy, publish, circulate or use any of the SSI Documents for any purpose other than performing the Work, without first obtaining the SFMTA's written approval to do so.

(c) **Disposal of the SSI Documents.** At the termination of the Contract, Contractor shall return all other sets of SSI Documents or destroy them.

13.1.8.c.1 SSI Documents shall be returned to the SFMTA using the contact information in Section 12.1.

13.1.8.c.2 If not returned to the SFMTA, the SSI Documents must be destroyed in a manner that ensures recovery of the information contained therein would be difficult, if not impossible. Any means approved for the destruction of national security classified material such as machine shredding, may be used to destroy the SSI Documents. If no such means is available, the SSI Documents may be destroyed by cutting or tearing them into small pieces and assimilating it with other waste material. Compact discs or other physical electronic media containing the SSI Documents shall be broken to pieces. Electronic files containing the SSI Documents or any portion of them shall be deleted in a manner that prevents recovery of the deleted documents.

13.1.8.c.3 Upon expiration or termination of the Agreement, Contractor shall certify to the SFMTA on a form to be provided by the SFMTA that all SSI Documents have been returned or destroyed as required herein. Submit signed certification to the SFMTA using the contact information in Section 12.1.

(d) **Liability for Failure to Secure or Misuse of the SSI Documents.** Contractor shall be fully liable for any and all harm and damages that may arise from unauthorized persons or entities gaining access to the SSI Documents due to or arising from Contractor's failure to adhere strictly to the requirements of this Section 13. In addition to civil liability, Contractor is cautioned that violation of applicable laws and regulations concerning protection and use of Sensitive Security Information may subject Contractor to federal penalties.

(e) **Subcontractors.** Contractor shall include the provisions of this Section in any agreement with any Affiliate, or subcontractor or Supplier that will require access to the SSI Documents, and Contractor shall be responsible for its Affiliates', subcontractors' and Suppliers' adherence to the requirements of this Section 13.

13.2. Management of City Data

13.2.1. Access to City Data. City shall at all times have access to and control of City Data and shall be able without Contractor's assistance to retrieve it in a readable format, in electronic form and/or print, at any time, at no additional cost.

13.2.2. Ownership of City Data. The Parties agree that as between them, all rights, including all intellectual property rights, in and to the City Data and any derivative works of the City Data is the exclusive property of the City.

13.2.3. Use of City Data

(a) Contractor agrees to hold City Data received from, or collected on behalf of the City, in strictest confidence. Contractor shall not use or disclose City Data except as permitted or required **by** the Agreement or as otherwise authorized in writing by the City. Any Work using, or sharing or storage of, City Data outside the United States is subject to prior written authorization by the City. Access to City Data must be strictly controlled and limited to Contractor's staff assigned to this Project on a need-to-know basis only.

(b) Contractor is provided a limited non-exclusive license to use the City Data solely for performing its obligations under the Agreement and not for Contractor's own purposes or later use. Nothing herein shall be construed to confer any license or right to the City

Data by implication, estoppel or otherwise, under copyright or other intellectual property rights, to any third-party.

13.2.4. Unauthorized Use. Unauthorized use of City Data by Contractor, Affiliates, subcontractors, or other third parties is prohibited. For purpose of this requirement, the phrase "unauthorized use" means the data mining or processing of data, stored or transmitted by the service, for commercial purposes, advertising or advertising-related purposes, or for any purpose other than security or service delivery analysis that is not explicitly authorized.

13.3. Litigation Holds. Contractor shall retain and preserve City Data in accordance with the SFMTA's instruction and requests, including, without limitation, any retention schedules and/or litigation hold orders provided by the SFMTA to Contractor, independent of where the City Data is stored.

13.4. Notification of Legal Requests. Contractor shall immediately notify the SFMTA upon receipt of any subpoenas, service of process, litigation holds, discovery, requests, and other legal requests (Legal Requests) related to City's Data under this Agreement, or which in any way might reasonably require access to City's Data, and in no event later than 24 hours after it receives the request. Contractor shall not respond to Legal Requests related to City without first notifying City other than to notify the requestor that the information sought is potentially covered under a non-disclosure agreement. Contractor shall retain and preserve City Data in accordance with the City's instruction and requests, including, without limitation, any retention schedules and/or litigation hold orders provided by the City to Contractor, independent of where the City Data is stored.

13.5. Disposition of City Data upon Termination. Upon request of City or termination or expiration of this Agreement, and pursuant to any document retention period required by this Agreement, Contractor shall promptly, but in no event later than 30 Days, return all City Data given to or collected by Contractor on City's behalf, which includes all original media. Once Contractor has received written confirmation from City that the City Data has been successfully transferred to City, Contractor shall within 10 Days clear or purge all City Data from its servers, any hosted environment Contractor has used in performance of this Agreement, including its Affiliates' and subcontractors' environment(s), work stations that were used to process the Data or for production of the Data, and any other work files stored by Contractor in whatever medium. Contractor shall provide City with written certification that such purge occurred within five Days of the purge. Secure disposal shall be accomplished by "clearing," "purging" or "physical destruction," in accordance with National Institute of Standards and Technology (NIST) Special Publication 800-88, or the most current industry standard.

ARTICLE 14 INCLUDED APPENDICES

The documents listed below are attached to this Agreement as Included Appendices and are incorporated into this Agreement by reference.

Appendix A – Contract Specifications

Appendix B – Schedule of Prices and Calculation of Charges

Appendix B1 – Schedule of Prices

Appendix B2 – Calculation of Charges

Appendix C – Milestone Schedule and Payment

Appendix D – Contract Schedule

Appendix E – Contract Changes

Appendix F – Performance Bonds

Appendix F1 – Performance Term Performance Bond

Appendix F2 – Support Term Performance Bond

Appendix G – Federal Contract Requirements

Appendix H – SFMTA SBE Requirements

Appendix I – Performance and Service Level Requirements

Appendix J – SFMTA Policies and Procedures

(1) SFMTA Track and Tunnel Access Procedures
(2) Barcoding Procedures
(3) Technology Change Control Policy and Procedures
(4) System Safety Rail Change Control Board Policy
(5) SFMTA Rail Rule Book
(6) Train Control System Upload Template
(7) SFMTA Technology Project Requirements

Appendix K –CBTC Software License Agreement

Appendix L – Reference Materials

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement on the day first mentioned above.

CITY	**CONTRACTOR**
San Francisco **Municipal Transportation Agency**	**Hitachi Rail GTS USA Inc.**
_____ Jeffrey P. Tumlin Director of Transportation	_____ [Name of Authorized Representative] [Title] [Optional: Address] [Optional: City, State, ZIP]
Authorized By: Municipal Transportation Agency Board of Directors Resolution No: _____ Adopted: _____ Attest: _____ Secretary to the Board	<u>Acknowledgement of Large Vehicle Driver Safety Training Requirements</u>: By signing this Agreement, Contractor acknowledges that it has read and understands Section 12.17: Large Vehicle Driver Safety Training Requirements.
Board of Supervisors Resolution No: _____ Adopted: _____ Attest: _____ Clerk of the Board	
Approved as to Form: David Chiu City Attorney By: _____ David F. Innis Deputy City Attorney	City Supplier Number: **[Supplier Number]**

APPENDIX A TO AGREEMENT

CONTRACT SPECIFICATIONS

FOR THE

DESIGN, PROCUREMENT, SYSTEM IMPLEMENTATION, SUPPORT AND RELATED SERVICES

FOR A

COMMUNICATIONS BASED TRAIN CONTROL SYSTEM

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1 SYSTEM OVERVIEW

1.1 PURPOSE

1. This Section provides Contractor an overview of the San Francisco Municipal Transportation Agency (SFMTA), its operations and the high-level objectives of the Project. This Section also provides a table of acronyms used in these Specifications.

1.2 SYSTEM OVERVIEW

1.2.1 SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY (SFMTA)

1. The SFMTA oversees the management of streets and ground transportation in San Francisco. SFMTA provides public transit services through its Transit Division, which is also known as the San Francisco Municipal Railway ("Muni"). Muni manages the Muni Metro, as well as all rail, bus, and cable car operations.

1.2.2 DESCRIPTION OF THE MUNI METRO SYSTEM

1. The Muni Metro System was assembled from a number of streetcar lines operated by Muni through the Twin Peaks Tunnel (constructed in 1917) and the Sunset Tunnel (constructed in 1928). The streetcar lines converged onto Market Street until the Bay Area Rapid Transit (BART) Project delivered the Market Street Subway in 1978 which connected to the Twin Peaks Tunnel at Castro (Eureka). With the opening of the Market Street Subway five streetcar lines (the J, K, L, M and N) were converted to light rail and began running fully under Market Street in 1982. Due to this heritage as a converted streetcar System, the Muni Metro was never conceived as a true "metro" with fully dedicated right of way along its entire alignment. In addition, because the conversion from streetcar to subway was an offshoot of the BART Project, the Muni Metro's design was narrowly focused to converge all lines into a single track in each direction downtown, as opposed to other major subway networks which disperse lines in patterns more resembling a grid. From this origin, today's Muni Metro has to overcome significant limitations on its capacity due to the way the System is laid out. The Muni Metro System is shown diagrammatically in Figure 1-1.
2. In the Market Street Subway, Twin Peaks Tunnel and the Central Subway, Trains are operated by the Automatic Train Control System (ATCS), which commands Train movements (that is, speed, braking and headway), signals and switches while operating in the subway. On the surface, Trains are operated manually by a Train Operator, who can request a routing through each isolated Junction or intersection using a Vehicle tagging system, named VETAG. This detection system sends a request to the adjacent Interlocking or traffic signal controller and provides permissive signaling and routing. Other rail Junctions in the system are completely manual operations, requiring field personnel on-site to physically throw the switch and wave a Train through using hand signals.

Figure 1-1: Muni System Map

1.2.3 TRAIN CONTROL UPGRADE PROJECT (TCUP)

1. The Train Control Upgrade Project (TCUP or Project) is a comprehensive capital program designed to improve Muni Metro light rail service by providing operations staff with the tools necessary to deliver reliable, speedy, high-frequency transit to, from, and in downtown San Francisco. The TCUP invests in the core rail system by replacing the 25-year-old Automatic Train Control System (ATCS) in the Market Street Subway while expanding modern train control to the surface.

2. The Project will deliver a new Communications Based Train Control (CBTC) System to replace the existing ATCS in the Subways and expand to the surface branches of the J, K, L, M, N and T lines to integrate the entire Muni Metro Light Rail network under one train control system.

3. The Project will employ Wi-Fi or cellular connections to precisely track and continually communicate with every Light Rail Vehicle (LRV) in service. The existing loop cable-based system in the subway will be removed. With the new technology, CBTC will manage Train movements throughout the entire 74-mile light rail network. In the subway, CBTC will operate in Automatic Train Operation (ATO) mode like the existing ATCS and use train regulation functions to adjust the speed and Dwell Time of Trains. On the surface, the CBTC System will operate in Automatic Train Protection (ATP) mode with Train Operators in control of the Train. CBTC's telecommunications technology will provide SFMTA Transportation Controllers with greater visibility and automation than the current ATCS, resulting in more effective Train management and better light rail service for the entire Muni Metro system.

4. Contractor shall deliver a CBTC System that provides the following benefits to SFMTA:

    a. Increase the capacity of the Market Street Subway by 20% compared to 2019 service levels, as measured by the maximum Trains per hour in peak hour service at Embarcadero eastbound platform.

    b. Maintain the same safety record as the existing automatic train control system in the subway, and extend modern safety protections (such as ATP) to surface operations.

    c. Enable more consistent travel times and headways compared to 2019 service levels, as measured by the variability of end-to-end running times for each Line during each service period (AM, PM, Midday, Evening).

    d. Provide a reliable train control system that supports Muni Metro service at all times it is operating, as measured by the RAM Performance Targets committed to in the Agreement.

    e. Provide maximum system flexibility to support the dynamic nature of transit operations, accommodate same-day service changes and contingency operations through Configuration and system tools.

1.3 SFMTA ACRONYMS AND ABBREVIATIONS

1. The following abbreviations and acronyms are used in these Contract Specifications.

Table 1-1: Acronyms and Abbreviations

Acronym	Meaning
AAA	Authentication, Authorization Accounting
AES	Advanced Encryption Standard
AGL	Above Ground Level
ALARP	As Low As Reasonably Possible
AMS	Asset Management System
ANSI	American National Standards Institute
AOQL	Average Outgoing Quality Levels
API	Application Programming Interface
APTA	American Public Transportation Association

Acronym	Meaning
AQL	Acceptable Quality Levels
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARS	Automatic Route Setting
A_s	System Availability
ASQ	American Society for Quality
ASR	Automatic Speed Regulation
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control
ATCS	Automatic Train Control System
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATPM	Automatic Train Protection Manual
ATR	Automatic Train Regulation
ATS	Automatic Train Supervision
ATS OSIM	ATS Operation Simulator
ATS Sim	ATS Simulator
BART	Bay Area Rapid Transit
BDA	Bi-Directional Amplifier
BITE	Built-In Test Equipment
C/I+N	Carrier to Interference
CA	Corrective Action
CAD	Computer-Aided Drawing
CAD/AVL	Computer-Aided Dispatch/Automatic Vehicle Location
CBA	Cost Benefit Analysis
CBTC	Communication Based Train Control
CCC	Construction Conformance Checklists
CCF	Common Cause Failure
CCTV	Closed-Circuit Television
CDL	Configuration Data List
CDR	Conceptual Design Review
CDRL or [CDRL]	Contract Data Requirements List (The notation “[CDRL]” in the text of the Specifications indicates a CDRL Deliverable.)
CENELEC	European Committee for Electrotechnical Standardization
CES	Customer Emergency Station
CFR	Code of Federal Regulations
CHA	Cutover Hazard Analysis
CMF	Common Mode Failure
CMP	Configuration Management Plan
CoC	Cut-over Cubicle
COTS	Commercial Off-The-Shelf

Acronym	Meaning
CPM	Critical Path Method
CPUC	California Public Utilities Commission
DBE	Disadvantaged Business Enterprise
DCN	Data Cable Network
DCS	Data Communication System
DED	Dumb End Devices
DNS	Domain Name System
DSSS	Dynamic Sequence Spread Spectrum
DVI	Digital Visual Interface
EAMS	Enterprise Asset Management System
EAP	Extensible Authentication Protocol
EB	Emergency Brake
ECT	Early Control Time
EDMS	Electronic Document Management System
EFN	Employee First Network
EFS	Equipment Functional Specifications
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ERP	Effective Radiated Power
ETEL	Emergency Telephone
FACI	First Article Configuration Inspections
FAT	Factory Acceptance Test
FC	Freight Crossing
FDP	Fiber Distribution Panels
FDR	Final Design Review
FEC	Forward Error Correction
FHSS	Frequency Hopping Spread Spectrum
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, & Criticality Analyses
FRA	Federal Railroad Administration
FRACAS	Failure Reporting and Corrective Action System
FRB	Failure Review Board
FSB	Full-Service Brake
FSR	Final Safety Report
FTA	Federal Transit Administration
FTP	File Transfer Protocol
GEBR	Guaranteed Emergency Brake Rate
GPS	Global Positioning System
GREEN	Green Division Muni Metro Maintenance Facility (yard)
GUI	Graphical User Interface

Acronym	Meaning
HCS	Hazard Communication Standard
HDD	Hardware Design Description
HMI	Human Machine Interface
HQAP	Hardware Quality Assurance Plan
HTTPS	Hypertext Transfer Protocol Secure
HVAC	Heating, Ventilation & Air Conditioning
HW	Hardware
I/O	Input/Output
ICD	Interface Control Document
ICMP	Internet Control Message Protocol
ID	Identity
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IHA	Interface Hazard Analysis
IMP	Integration Management Plan
IP	Intellectual Property
IPS	Intrusion Prevention System
ISA	Independent Safety Assessor
ISO	International Organization for Standardization
ISR	Interim Safety Report
IT	Information Technology
ITPP	Inspection and Test Program Plan
ITU	International Telecommunication Union
KPI	Key Performance Indicator
L2TP	Layer 2 Tunneling Protocol
LAN	Local Area Network
LCF	Loss of Critical Function
LCP	Local Control Panels
LLRU	Lowest Line Replaceable Unit
LMA	Limit of Movement Authority
LMS	Learning Management System
LMY	Lost Minutes per Year
LORA	Level Of Repair Analysis
LRU	Line Replaceable Unit
LRV	Light Rail Vehicle
LRV 4	Light Rail Vehicle – 4 (Siemens)
LSHF	Low Smoke Halogen Free

Acronym	Meaning
MAC	Message Authentication Code
MCG	Modular Communication Gateway
MCMT	Mean Corrective Maintenance Time
MDT	Mean Downtime
MFA	Multiple Factor Authentication
MIL	Material Items List
MIL STD	Military Standard
MM	Muni Metro
MME	Muni Metro Maintenance Facility East (Yard)
MMT	Muni Metro Turnback
MPMT	Mean Preventive Maintenance Time
MRA	Manual Route Authorization
MRS	Manual Route Setting
MTBF	Mean Time Between Failures
MTBHE	Mean Time Between Hazardous Events
MTBSAF	Mean Time Between Service Affecting Failures
MTRE	Mean Time to Restore
MTTR	Mean Time To Repair
$MTTR_{max95}$	Maximum Mean Time To Repair
MUT	Mean Uptime
MVB	Multifunction Vehicle Bus
NCO	Non-Communicating Obstructions
NCR	Non-Conformance Report
NCT	Non-Communicating Trains
NEMA	National Electrical Manufacturers Association
NEMS	Network Elements
NERC	North American Electric Reliability Council
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NMS	Network Management System
NSS	Network Security System
NTP	Notice To Proceed or Network Time Protocol
O&M	Operations and Maintenance
O&SHA	Operating & Support Hazard Analysis
OCC	Operations Control Center (former OCC near West Portal)
OCS	Overhead Catenary System
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OLT	Optical Loss Test
OMP	Obsolescence Management Program

Acronym	Meaning
OrbCAD	Computer Aided Dispatch
OS	Operating System
OSHA	Occupational Health & Safety
OSL	Operating Speed Limit
OWASP	Open-Source Web Application Security Project
PAP	Password Authentication Protocol
PAV	Platform Audio Visual
PBX	Private Branch Exchange
PCB	Printed Circuit Board
PCC	President's Conference Committee
PDR	Preliminary Design Review
PET	Passenger Emergency Telephone
PHA	Preliminary Hazard Analysis
PICO	Post Installation Check Out
PIN	Personal Identification Number
PLC	Programmable Logic Controller
PM	Preventive Maintenance
PMP	Project Management Plan
PP	Patch Panel
PTASP	Public Transportation Agency Safety Plan
PTE	Portable Test Equipment
QA	Quality Assurance
QAM	Quality Assurance Manual
QAPP	Quality Assurance Program Plan
QC	Quality Control
QMR	Quality Management Report
QoS	Quality of Service
RAM	Reliability, Availability, and Maintainability
RAMS	Reliability, Availability, Maintainability, and Safety
RBAC	Role Based Access Control
RBD	Reliability Block Diagram
RCA	Root Cause Analysis
RDS	Remote Data Service
RF	Radio Frequency
RFI	Radio Frequency Interference or Request for Information
RFQ	Request for Quotes
RGS	Rigid Galvanized Steel
RMDT	Reliability and Maintainability Demonstration Testing
ROM	Reduction in Operating Margin
ROW	Right-of-Way

Acronym	Meaning
RSA	Restricted Security Area
RTM	Requirements Traceability Matrix
SAF	Service Affecting Failure
SAP	Software Assurance Plan
SBE	Small Business Enterprise
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SEMP	System Engineering Management Plan
SFCTA	San Francisco County Transportation Authority
SFD	System Functional Description
SFMTA	San Francisco Municipal Transportation Agency
SHA	System Hazard Analysis
SHPO	State Historic Preservation Officer
SIEM	Security Information and Event Management
SLMD	Second Line Maintenance Devices
SMP	Support Management Plan
SOP	Standard Operating Procedure
SPC	Statistical Process Control
SPMP	Software Project Management Plan
SQAP	Software Quality Assurance Plan
SQL	Structured Query Language
SRAC	Safety Related Application Condition
SRD	System Requirement Specifications
SSCP	Safety and Security Certification Plan
SSCR	Safety and Security Certification Report
SSCVR	Safety and Security Certification Verification Report
SSHA	Subsystem Hazard Analysis
SSI	Solid State Interlocking
SSID	Service Set Identifier
SSM	Signal System Emulator
SSMP	SFMTA Safety and Security Management Plan
SSP	System Security Plan
SSPP	System Safety Program Plan
SSQMP	Support Services Quality Management Plan
SSRD	Subsystem Requirements Specification
SSS	System Support Specialist
SVD	Software Version Description
SVVP	Safety Verification and Validation Plan
SVVR	Safety Verification and Validation Report
TACACS	Terminal Access Controller Access Control System

Acronym	Meaning
TCN	Temporal Convolution Network
TCP	Transmission Control Protocol
TCUP	Train Control Upgrade Project
TDM	Transportation Demand Management
TIA/EIA	Telecommunications Industry Association / Electronic Industries Alliance
TIDS	Track Intrusion Detection System
TLS	Transport Layer Security
TMC	Transportation Management Center
TOD	Train Operator Display
TSC	Traffic Signal Controllers
TSI	Technology Solutions & Integration
TSOR	Temporary Safe Operating Procedures
TSR	Temporary Speed Restriction
TVA	Threat and Vulnerability Assessment
TVM	Ticket Vending Machine
TVTL	Threat and Vulnerability Tracking List
TWC	Train to Wayside Communication
UDP	User Datagram Protocol
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
UTO	Unattended Train Operation
V&V	Verification and Validation
VLAN	Virtual Local Area Network
VOBC	Vehicle On-Board Controller
VOIP	Voice Over Internet Protocol
VPI	Vital Processor Interlocking
VPN	Virtual Private Network
VSWR	Voltage Standing Wave Radio
VTSim	Vehicle Training Simulator
VVR	Verification and Validation Report
WBS	Work Breakdown Structure
WN	Wireless Network
XML	Extensible Markup Language
XSS	Cross Site Scripting
XXE	XML External Entry
ZC	Zone Controller
ZCSim	Zone Controller Simulator

1.4 DEFINITIONS

1. The following definitions apply to this Agreement. Where any word or phrase defined below, or a pronoun in place of the word or phrase, is used in any part of this Agreement, it shall have the meaning set forth below. The General Provisions, Article 2, and the Software License Agreement contain additional defined terms, which are incorporated here by reference.

Table 1-2: Definitions

Term	Definition
Acceptance	As defined in Article 2 of the Agreement
Active Cab	Operating compartment of a rail Vehicle from which control of the Vehicle is achieved.
Active Directory	Active Directory is a database and set of services that connect users with the network resources required to complete their work. The database (or directory) contains critical information about the network environment, users, computers and authorization.
Agency	As defined in Article 2 of the Agreement
Agreement or Contract	As defined in Article 2 of the Agreement
"All Clear" Communication	Notification that the change has been fully implemented and checked, and there is no further risk to SFMTA production systems
Application Programming Interface (API)	A set of subroutine definitions, protocols, and tools for building application Software. An API allows two applications to talk to each other.
Asset ID	A unique ID for each part/asset provided by the SFMTA EAMS System for ongoing use in the Project and SFMTA (Section 13.5.2 item 3)
Asset Management System (AMS)	The Contractor's system for maintenance and diagnostic functions meeting the description provided in Section 20.2.
ATO Start Button	A button in the Vehicle console which starts Automatic Train Operation (ATO) mode
ATO Territory	The portion of CBTC Territory where ATO mode is available as defined in Section 22.3, excluding UTO Territory.
Automatic Train Control System (ATCS)	As defined in Article 2 of the Agreement
Automatic Train Operation (ATO)	The functions within the ATC system that performs speed regulation, programmed stopping, door control, performance level regulation, or other Train operation related actions.
Automatic Train Protection (ATP)	The functions within the ATC system that maintains fail-safe protection against collisions, excessive speed, and other hazardous conditions through a combination of train detection, train separation, and interlocking.

Term	Definition
Automatic Train Supervision (ATS)	The subsystem within the ATC system that monitors Trains, adjusts the performance of individual Trains to maintain schedules, and provides data to adjust service to minimize inconveniences otherwise caused by irregularities. (IEEE 1474.1).
Automatic Turnback	A feature where the CBTC operates an out of service Train in UTO mode between a terminal platform and a pocket or tail track
Automatic Turnback Consoles	As described in Section 16.3.1.6 and Section 27.8.4.6
Availability or System Availability	The probability that the CBTC system is capable of operating and performing its intended function at a random point in time; shown as "A_s" in Section 30.7.2, item 1.e.
Back-end Infrastructure	Refers to the infrastructure that includes server, application and database that works in the background to deliver information to the end user. The infrastructure can take the form of servers, mainframes, and other system that offer data services.
Base Product	Contractor's standard SelTrac™ CBTC product that the Contractor will use to meet the requirements contained in these Contract Specifications, before any Customization or adaptation to a specific client.
Berth	Space designated for a Train of given length to occupy when it is stopped at a station platform, in a terminal or at some other designated location, or the act of occupying this space.
Bill of Materials	List of all the Materials and parts that are needed to make, build or produce a product or assembly
Block ID	As defined in Section 17.2, paragraph 22.b.ii
Brake, Emergency	Maximum braking effort that can be obtained which includes Friction and Track Brake. Once activated, Emergency Brakes cannot be released until the Train has come to a complete stop.
Brake, Full Service	Combination of dynamic and friction braking used for normal stopping without the Emergency Brake.
Bunching	When two or more Vehicles are convoying at the minimum ATP safety distance, such that the following Vehicle(s) stops on the guideway when the front Vehicle is stopped at the station platform
CBTC Modes of Operation	As defined in Section 22
Communications Based Train Control System (CBTC)	As defined in Article 2 of the Agreement
CBTC System Line Overview	As defined in Section 17.3.2.1
CBTC Territory	As defined in Section 2.2.2
CDRL or [CDRL]	Contract Data Requirements List (CDRL) means an individually documented contractual deliverable.

Term	Definition
Central Control	The active and staffed Control Center, either TMC or OCC. When this term is used in a requirement, e.g., "Train positions shall be visible from Central Control", it refers to all facilities that are capable of acting as the active Control Center.
Central Equipment	Equipment located in SFMTA Control Centers, data centers, control rooms, and other non-wayside locations.
Certifiable Elements	All CBTC System elements that can affect the safety and security of transit agency passengers, employees, contractors, emergency responders, or the general public; including System-wide elements, fixed facilities, and Plans, Procedures, and Training.
Certificate of Compliance	As defined in Section 5.3.4
Change Control Board	As specified in Section 15.2
Change Control Process	As defined in Section 15.4
Change Request	As defined in Section 15.2.2
Closures	As defined in Article 2 of the Agreement
Commissioned or Commissioning	As defined in Article 2 of the Agreement
Common Cause Failures	A Common Cause Failure (CCF) is any coincident failure on the same cause arising from an identical or underlying cause.
Common Mode Failures	A Common-mode Failure (CMF) is any coincident failure on the same mode where the failure has an identical appearance or effect.
Conceptual Design	As defined in Section 4
Conditional Acceptance	As defined in Article 2 of the Agreement
Configurable or Configuration or Configure	As defined in Article 2 (Definitions) of the Agreement.
Consequential Event	An Event that occurs because of another event in the context of failure. For example, a second failure occurring because of an initial failure is considered to be consequential event.
Consist	The number and specific identity of LRVs that make up a Train.
Consist ID	As defined in Section 17.3.3.1, paragraph 4
Construction Documents	A set of detailed engineering Drawings and documents which provide all information necessary for an Installer to install the portion of the System to be delivered in a Phase, such as engineering Drawings, installation instructions, and material specifications.
Construction Final Design	As defined in Section 4.2.4

Term	Definition
Construction Final Design Period	As defined in Section 8.3.2.1
Construction Final Design Review	The formal Design Review of Contractor's complete 100% design, installation and construction documents, culminating in approval of the Construction Final Design by SFMTA
Contractor	As defined in Article 2 of the Agreement
Contract Documents	As defined in Article 2 of the Agreement
Contract Specifications	As defined in Article 2 of the Agreement
Contract Term	As defined in Article 2 of the Agreement
Control Center	Means both the Transportation Management Center and Operations Control Center.
Critical Command	Commands initiated by the ATS that require added level of safety by requiring the Transportation Controller to confirm the initiated command multiple times through different means (i.e., clicking on the prompt and typing the command in different screen) to reduce the likelihood of mistake or wrong implementation resulting in a Hazard
Critical Functions	All functions that are initiated by a Transportation Controller through ATS are considered Critical Functions.
Critical Path Method (CPM)	Method of schedule development where the duration and sequence of all schedule activities are logically related such that the series of activities that provide the longest continuous sequence from the schedule start date to the schedule end date is shown.
Customer Information System	An automated system for supplying users of public transport with information about the nature and the state of a public transport service through visual, voice or other media.
Customization	As defined in Article 2 (Definitions) of the Agreement.
Cutover Cubicle	As defined in Section 27.8.3
Data Communication	As defined in Section 26
Data Warehouse	As defined in Section 28.4.1
Defect	As defined in Article 2 of the Agreement.
Defense in Depth	A type of cybersecurity in which several independent layers of security controls are used so that if one fails another will be operative.
Deliverable	Means one or more items specified in the Contract Documents that the Contractor shall complete and deliver or submit to SFMTA for acceptance. Deliverables are identified in the CDRLs in these Specifications. See CDRL.
Deployment	Refers generally to the installation and testing activities required to introduce Contractor Equipment into SFMTA operations.
Deployment Phase	As defined in Article 2 of the Agreement

Term	Definition
Design Life	The duration of time that the System, subsystem, or component is expected to work within its specified parameters.
Design Life Cycle	As defined in Section 4.2
Design Phase	As defined in Section 4.2
Design Reviews	As defined in Section 4.2
Detection-in-Depth	The implementation of numerous detection points within an attack chain which will increase the likelihood that the attacker will trigger one or many of the detections created.
Dodge Roaming Tables	A set of sampling. inspection tables for lot-by-lot inspection of product by attributes using two types of sampling plans, plans for lot tolerance percent defective (LTPD) protection and plans that provide a specified average outgoing quality limit (AOQL)
Downtime	Period of time where full operational functionality is not available
Drawbridges	As described in Section 28.8.2
Drawings	Technical drawing with graphical representations that conveys the engineering content of the scope
Dwell	A condition where the Train is in-service, stopped at a stop or platform with the doors open, the steps in the correct position, and assigned to a Service Line in the ATS system. The Train can be expected to be loading/unloading passengers during the Dwell.
Dwell Time	The duration of time a Train Dwells at a station or stop measured as the interval between doors open and the authorization for the door close command.
Earned Value	Budgeted cost of worked performed; to obtain cost and schedule performance, which provides information on how well the project is doing or performing relative to its original plans.
Employees-In-Charge	SFMTA employee with responsibility for supervising and ensuring safety
End of Support	A designation for Software where the developer stops updating and patching the Software, and stops all maintenance, troubleshooting or other support.
Energy Saving	As defined in Section 16.3.1.11
Engineer of Record	The responsible person for design and construction Phases of a project who is also a professional engineer currently registered in the state of California for the applicable discipline
Equip	To provide Equipment but not install it
Equipment	As defined in Article 2 of the Agreement
Expansion Phase	Refers to the N, T, K&M, J and L Expansion Phases
Fail-Operational	As defined in Section 30.2 item 3
Fail-Safe	“Fail Safe” means that the System shall inherently and automatically (i.e., without human intervention) immediately default to a “safe” state when the System detects any failure with the potential for harm. The System shall have no single point of failures that leads to an unsafe System state. “Safe”, in this context, means a state in which persons, infrastructure and vehicles are not at risk of harm.

Term	Definition
Failure Review Board	A board intended to review and decide on chargeability of deployed (in service) CBTC System failures with the format specified in Section 30.2.2.1
Final Acceptance	As defined in Article 2 of the Agreement
Final Design Review	As defined in Section 4
First-level Maintenance	All maintenance activities that are performed directly on Equipment without specialized training, including but not limited to repairing, inspecting, servicing, calibrating, lubricating, or adjusting. See Section 32 (Support Services).
Flat File Database	A database stored in a file called a flat file. Records follow a uniform format, and there are no structures for indexing or recognizing relationships between records.
Freeware	Software that is available free of charge
Furnished Items	Items provided by SFMTA to Contractor to be used in the Project.
General Order	Rail transit safety and security legislation issued by the California Public Utilities Commission.
GoA1, GoA2, GoA4	Grades of Automation, as defined and described in IEC 62267
Grouping Kit	Grouping Kit consists of all Materials required to ground an electrical system
Hardware	Equipment
Hazard	Any condition that can cause injury, illness, or death; damage to or loss of the facilities, Equipment, rolling stock, or infrastructure of SFMTA; or damage to the environment.
Heritage Vehicles	As defined in Section 2.4.2, paragraph 1.
In House	Internal to SFMTA, without assistance from outside an organisation. Used to denote SFMTA self-performed activities
Incident	Unforeseen event or occurrence.
Independent Safety Assessor	An independent consultant selected by the SFMTA to undertake and perform the safety assessment of the System delivered under the Contract in order to obtain an independent professional judgement that the System is safely designed, furnished, installed, tested, and Commissioned.
Inspection and Test Program	As specified in Section 5.5.1
Inspection and Testing Requirements	As specified in Section 5.5.1
Installation Activities	As specified in Section 8.5.1 item 1
Installation Period	As defined in Section 4.2.6
Installation RFI	An RFI issued by SFMTA that is connected to an RFI that SFMTA received from one of its Installers. Installation RFIs will be marked.
Installation Specifications	Documentation that describes how a product should be properly installed within a physical environment that includes Materials to use or Bill of Materials, installation details/instructions, tools or Equipment required, and level of quality.

Term	Definition
Installer	As defined in Article 2 (Definitions) of the Agreement. Refers to both Vehicle and Wayside Installers.
Installer Punch List	As specified in Section 8.5.1.1 items 5 & 6
Interlocking	An arrangement of switch, lock, and signal devices that is located where rail tracks cross or where two or more rail tracks converge or diverge. The devices are interconnected in such a way that their movements must succeed each other in a predefined order, thereby preventing opposing or conflicting Vehicle movements. "
Interlocking Local Control Panel	Local Control Panels that are located on the platform to locally operate the related Interlocking
ITU/R	International Telegraph Union (ITU) sector that manages the international radio-frequency spectrum and satellite orbit resources
ITU/T	International Telegraph Union (ITU) sector that standardizes global telecommunications
Junction	A place at which two or more rail routes converge or diverge
Key Personnel	As defined in Article 2 of the Agreement
Learning Management System	The information system used by the City and County of San Francisco for employee training, more information at https://sfdhr.org/employee-online-trainings
Light Rail Vehicle (LRV) or Light Rail Vehicle 4 (LRV4)	As defined in Article 2 of the Agreement.
List of Effective Pages	A list of every page in a document along with the current revision number and the date of each page's revision.
Local Control Panel Operator	SFMTA employee who operates locally certain Interlockings using the Local Control Panels
Maintenance Vehicle	The fleet of hi-rail vehicles maintained by the SFMTA for use in maintenance.
Malware	Any type of malicious software designed to harm or exploit any programmable device or network
Materials	As defined in Article 2 (Definitions) of the Agreement.
Migration	Refers to activities that provide operational guidance to bring the new CBTC System into Revenue Service
Milestone	As defined in Article 2 of the Agreement
Monthly Support Fee	The fee paid by SFMTA in exchange for the Support Services each month, as calculated using the procedures in Appendix B to the Agreement.
Muni	Services operated by the Transit Division of the SFMTA.
Muni Metro Turnback (MMT)	Designated location east of Embarcadero Station where special trackwork and pocket tracks are utilized for turnback purposes.

Term	Definition
Non-Conformance	Failure to comply with a requirement / specification, standard, or procedure
One-team Approach	A specific approach where in the Contract and SFMTA staff are integrated as much as possible so as to form a single team. The team adopts a problem-solving mentality working towards a set of shared goals (efficient management of the railway and minimizing delays).
Open Items	As specified in Section 31.4.3
Operations Control Center or Old Control Center (OCC)	The facility located at 151 Lenox Way near West Portal Station, which acts as the backup Control Center for Muni's bus and rail operations and the training facility for Train Controllers.
Overspeed Condition	A condition where the Train's speed exceeds the Civil Design Speed for the section of guideway it is traveling on.
Owner's Representative	An SFMTA employee who has been designated by the Director of Transit to represent SFMTA to Contractor, following the completion of the project
Parts Count	A Reliability prediction method based on the generic failure rates of components that were calculated using certain default parameter values
Performance Metric	Means the System Performance criteria and methodologies. See Section 30 (Reliability, Availability and Maintainability).
Performance Requirement	As defined in Article 2 (Definitions) of the Agreement.
Performance Target	As defined in Article 2 (Definitions) of the Agreement.
Phase	As defined in Article 2 (Definitions) of the Agreement. The word "Phase" on its own is distinguished from "Deployment Phase" which is a subset of Phases.
Pilot	Trial undertaking prior to full scale operation or use; done as a test before introducing something more widely
Pilot Deployment Phase or Pilot Phase	Means the first Deployment Phase, corresponding with the surface segment along the Embarcadero and northern Third Street corridor, over which the first complete portion of the System (with central Equipment, wayside, and onboard components) will be tested and Commissioned. See Section 8 (Deployment, Migration and Acceptance).
Pilot Operating Period	Means the period immediately after Pilot Deployment Phase Commissioning, in which the SFMTA is operating the CBTC in Revenue Service on a trial basis. See Section 8 (Deployment, Migration and Acceptance).
Platform Operator	SFMTA operations staff located at the platform who can command a Train to depart from the station/platform by pressing the button on the Train Depart Local Control Panel Console
Playback	Replay recorded sound and picture from ATS OSIM and revenue CBTC System; as specified in Section 21.2.4
Preliminary Design	As specified in Section 4
Preventive Maintenance	Scheduled, regular or planned maintenance activity which is not conducted in direct response to a known or suspected failure.

Term	Definition
Procurement Term	Means the initial nine-year period of the Contract Term, during which Contractor shall design, procure, oversee installation, test, certify and implement the CBTC System into Revenue Service. (See Article 3 (Contract Term) and Appendix A (Contract Specifications) of the Agreement.) The Procurement Term ends at Final Acceptance.
Project	As defined in Article 2 of the Agreement
Proposal	As defined in Article 2 of the Agreement
Public Marketplace	An online directory, catalog or a place where multiple sellers can list their products for sale
Quantitative Analysis	Any analysis which leads to evaluation of System Configuration in any state to produce a numerical result representative of System Reliability or maintainability.
Ransomware	Ransomware is a type of Malware that prevents or limits users from accessing their system, either by locking the system's screen or by locking the users' files until a ransom is paid
Reduction in Operating Margin	As specified in Section 30.2.1 item 4
Reimbursable Parts	As defined in Article 2 (Definitions) of the Agreement.
Reliability	The ability that a product, system, or service will perform its intended function, without failure, adequately for a specified period of time under given condition
Reliability, Availability, and Maintainability (RAM)	As defined in Article 2 (Definitions) of the Agreement.
Revenue Service	As defined in Article 2 of the Agreement
Roadmap	Visual representation of the strategic plan that defines a goal or desired outcome and includes the major steps or milestones needed to reach it
Root Cause	As specified in Section 30.2.3
Safety Certification	As specified in Sections 6.2 and 6.3
Safety Critical	A term applied to a system or function, where its correct performance is critical to safety of personnel and/or equipment and the incorrect performance of which may result in a Hazard.
Scope of Work	Means Work, as defined in Article 2 of the Agreement
Second-level Maintenance	Means all maintenance activities that are performed by SFMTA personnel on Equipment removed from the System. See Section 32 (Support Services).
Second Line Maintenance Device (SLMD)	Means a tool used during maintenance of components or sub-components of the CBTC, which can be scheduled on a regular basis or used for unscheduled and on-call maintenance. A SLMD provides diagnostics to troubleshoot issues with the functions of components or sub-components of the CBTC.
Section	A chapter of the Contract Specifications containing similar scope. Sections of the Contract Specifications may be cross referenced throughout the Contract.

Term	Definition
Service Affecting Failure	As specified in Section 30.2.1 item 2
Service Line, or Service Line Assignment	Muni Metro lines, for example, J, K, L, M, N, T, S, X-out of service
Service Pattern	The path or routes to be taken through CBTC Territory from Trip origination to destination, including stations and stops served. Service patterns are associated with a Line and their description includes the destination.
SFMTA TSI	SFMTA's Technology Solutions and Integration Department, SFMTA's department responsible for technology, network systems, middleware, cybersecurity, integration, etc.
Shadow Mode	As specified in Section 31.7.5
Shop Materials	As defined in Article 2 (Definitions) of the Sample Agreement.
Significant Failure	A failure that requires unplanned intervention by any authorized person acting on behalf of Contractor or on behalf of SFMTA, occurring in any product, system, sub-system of any Hardware, Software or functional failure in the CBTC System, resulting in any unscheduled or early withdrawal from Revenue Service (even if an on-time arrival at a mid-point or terminal destination is achieved). If any reset action takes in excess of 5 minutes or any other manual intervention with the product or its output is deemed necessary to re-establish function or service that takes greater than 5 minutes, then the failure shall also be categorized as 'Significant'
Software	As defined in Article 2 of the Agreement
Software Bug	An anomaly (e.g., Software Error, Defect, Software Fault, Software Failure, or Software Problem) in the design, development, or operation of Software that causes it to produce an incorrect or unexpected result, or to behave in unintended ways. For the purposes of identifying Software Bugs in relation to the provisions of this Agreement, a Software Bug exists any time the System does not behave as described in the System manuals and/or Contract requirements, or if the Software is unable to perform a function described in the System manuals, CDRLs, and/or Contract Specifications. This definition of Software Bug includes features described in the System manuals, CDRLs, and/or Contract Specifications which do not exist in the System Software as Software Bugs. See also definitions for Software Error, Defect, Software Fault, Software Failure, and Software Problem for distinguishing characteristics.
Software Error	A human action that produced an incorrect result, such as Software containing a Fault.
Software Failure	The inability of the System or System component to perform a required function within the specifications, including the termination of a previously demonstrated ability of a product to perform a required function, or an inability to perform within specified limits, or the departure of System operation from System requirements. A Failure may be produced when a Fault is encountered and a loss of the expected service results.

Term	Definition
Software Fault	A Defect in the code that can be the cause of one or more Failures or a manifestation of an Error in the software. Systems may be designed to be Fault-tolerant such that a Software Fault does not result in a Software Failure.
Software Problem	Difficulty or uncertainty experienced by one or more persons, resulting from an unsatisfactory encounter with the System.
Special Tool	Tools that are not commercially available from multiple general Hardware Suppliers in the United States
Standard	Repeatable, agreed and documented methods, processes, measures or other criteria defined and codified by internationally recognized associations, professional bodies in the respective fields, or SFMTA's internal standards and includes best practices
State of Good Repair	The condition in which a capital asset can operate at a full level of performance.
Street Territory	The portion of CBTC Territory where Street mode is available as defined in Section 22.3, excluding ATO Territory.
Subcontractor	As defined in Article 2 of the Agreement
Subway Cutover	Means the action, following SFMTA approval, of permanently cutting over control of the subway wayside signaling systems to the Contractor's CBTC System, and disconnecting the existing system. See Section 8 (Deployment, Migration and Acceptance).
Supplier	A firm which Contractor uses to source COTS components, but which does not contribute to the design.
Support	As specified in Section 32
Support Services	As defined in Article 2 (Definitions) of the Agreement.
Support Term	As defined in Article 2 of the Agreement
System	Means the CBTC, is as defined in Article 2 (Definitions) of the Agreement.
System Design Documents	A set of Drawings and other documents necessary to describe how the requirements transform into more technical system design specifications from which the System is built. The System Design Documents describe the high-level System design.
System Final Design	As specified in Section 4.2.3
System Performance	As defined in Article 2 (Definitions) of the Agreement.
Tangible Financial Asset	Parts considered to have physical form such as equipment and machinery
Test Train	Train used to verify the safe operational status of mainline track or other systems.
Testing and Commissioning Period	As specified in Section 8
Third-Party Systems	Technology systems provided to SFMTA by third parties, as listed in Table 28-1.

Term	Definition
Track Section	A portion of track in CBTC Territory that is a uniform length. Used as a unit measure by the CBTC System to define Work Zones, Slow Zones, etc.
Traction Power Section	The area of CBTC Territory that is connected to the same power feeder(s).
Train	Two or more LRVs coupled together or a single LRV operating as a single Vehicle. A Train will have a single Train Operator and a single active cab.
Train ID	Train identification number in the CBTC System
Trainline	Electric and pneumatic coupling between LRVs allowing signal transmission to all LRVs in a Train.
Train Operator	SFMTA employee who is authorized to operate a Train
Train Operator Display (TOD)	The built-in user interface for use by Train operators in the Siemens' LRV4 vehicles.
Transportation Controller	Designated employee on-duty at Control Center having authority over Vehicle movements and other activities affecting mainline operations.
Transportation Management Center (TMC)	The facility at 1455 Market Street used as the primary Control Center for Muni's bus and rail operations.
TSR Zone	The section(s) of track where a Temporary Speed Restriction is active, as specified in Section 16.3.1.9.
Trapeze	Commercially available scheduling software from Trapeze Group company
Trip	A single one-way journey of a Vehicle in Revenue Service between two terminals using a defined Service Pattern. A Trip has a distinct identification number in the schedule data maintained by the CAD/AVL system. Schedule Blocks contain a list of sequential Trips.
Tunnel Ventilation Section	A portion of the subway served by a single tunnel ventilation shaft.
Type Tests	As specified in Section 31.5
Unattended Train Operation (UTO)	One of four CBTC Train operating modes selected by the switch position in the cab of the Train. This mode allows the CBTC to operate the Train without a Train Operator on board in specific locations as described in Section 22
Update	As defined in Article 2 of the Agreement
Upgrade	As defined in Article 2 of the Agreement
Uptime	Period of time where full operational functionality is available
Useful Life	The duration of time that the System, subsystem, or component is expected to function in Revenue Service before needing to be replaced.
UTO Territory	The portion of CBTC Territory where UTO mode is the normal operating mode, as defined in Section 22.3.
Vehicle	As defined in Article 2 (Definitions) of the Agreement.
Vehicle ID	Permanent identification number of a Vehicle, which matches the number painted on the Vehicle.

Term	Definition
Vehicle Installer	A firm that SFMTA has contracted with to install the CBTC Equipment on board the LRV4s.
Vital	A function in a safety-critical system that is required to be implemented in a Fail-Safe manner.
VOBC ID	Identification number of a Vehicle's VOBC, which shall be set to match the Vehicle ID.
Warranty Period	As specified in Section 13
Warranty Services	As defined in Contract Specifications Section 13.2, paragraph 4
Wayside Installer	As specified in Section 8.5.1.1
Work	As defined in Article 2 of the Agreement.
Work Zone	An area of track construction, maintenance, or utility-work activities
Working Group	Group of people (workgroups) from relevant engineering discipline for the purpose of design interface, review and integration and/or construction workgroups for the purpose of coordinating access for installations and/or testing execution.

2 SUMMARY OF WORK & SCOPE SPLIT

2.1 PURPOSE; INTERPRETATION AND CONSTRUCTION OF SPECIFICATIONS

1. This Section provides a general description of Contractor's and others' overall Scope of Work for the Project. Unless the Contract expressly states that the SFMTA is the actor or party responsible for the action, report, Deliverable, Contract obligation, or other element of the Project, the Contract shall be interpreted to mean that Contractor is the actor or party contractually responsible for the action, report, Deliverable, or other element of the Project.

2.2 SUMMARY OF WORK

2.2.1 GENERAL SCOPE OF WORK

1. Contractor shall design, develop, Furnish, test, commission, and Support a complete turnkey CBTC System across the entire mainline of the Muni Metro System as described and specified in the Agreement.

2. Contractor's CBTC System design shall meet the Performance, Reliability, Availability, Maintainability, Safety and Security requirements of the San Francisco Municipal Transportation Agency (SFMTA) as stated in these Specifications.

3. The CBTC System shall have a minimum Design Life of 20 years following Final Acceptance.

4. Contractor's Scope of Work does not include installation of Contractor supplied Equipment.

    a. Contractor shall work in collaboration with SFMTA and Equipment Installers contracted separately by the SFMTA.

    b. Contractor shall monitor and inspect Installer's work as provided in Section 2.5 (Support of Installation Activities).

5. The SFMTA operates an active railway. To the maximum extent possible, Contractor shall perform its Work, including surveys, installation, testing and Commissioning activities, to avoid, limit and mitigate interference with and impacts to SFMTA's operation and maintenance activities. See Section 8.2 for requirements concerning interference with SFMTA operations and maintenance.

6. Contractor's Scope of Work includes design services, and these Specifications are performance based. Multiple design approaches may meet the requirements stated in these Specifications. Contractor shall collaborate closely with SFMTA during the design process, communicate key design decisions, and allow SFMTA to make design input in advance of formal submittals. SFMTA may withhold approval for submissions which are inconsistent with previous approved designs, CDRLs, and submissions, or which are inconsistent with the approach described in Contractor's Proposal.

7. Contractor shall respond to all SFMTA comments made during reviews and revise its designs, CDRLs and submissions as necessary to address SFMTA's comments. See Section 3.5.1.4 for SFMTA review process.

8. Contractor shall perform the Work in accordance with these Specifications and other Contract requirements and applicable Standards to deliver the CBTC System to SFMTA within the Contract Amount and within the time limits stated in the Agreement.

9. Contractor shall provide all management, technical staff, and other resources necessary to perform Project Management, Project Engineering, and Quality Assurance and Control, to deliver to SFMTA

a CBTC System that meets Contract requirements, including but not limited to System Reliability, Availability, and Maintainability (RAM), Operations and Maintenance, Safety and Security, Information Technology, and Training.

10. The Contractor is responsible for obtaining all of the necessary information from the field surveys needed to complete the CBTC system design, vehicle designs, and construction final design as defined in Section 4.2 (Design Lifecycle) The Contractor shall, for each field survey:

    a. Plan and schedule the survey.

    b. Define survey objectives.

    c. Select the survey methods to be used.

    d. Prepare survey materials and furnish any instrumentation needed.

    e. Perform all data collection; conduct interview(s) or observations and record data.

    f. Summarize findings in a report.

11. As part of its field surveys, Contractor shall note the material condition of any and all SFMTA Furnished Items that are integral to the Contractor's design approach. Contractor shall identify any items that are not serviceable and must be replaced before installation of the CBTC System. SFMTA will replace the equipment in accordance with its commitments under this Agreement or the parties will agree on an alternative design which avoids the use of unserviceable equipment.

2.2.2 CBTC TERRITORY

1. CBTC Territory shall include all mainline tracks, including tail tracks, cut-out wye and half grand union tracks up to and including the transition zone between the mainline and the maintenance yards. The maintenance yards are not part of CBTC Territory except for the test tracks in both the Green and MME rail yards. The CBTC Territory is comprised of Subway (or tunnel) and Surface (or non-tunnel) areas.

2. Tracks or portions of the SFMTA rail network outside of CBTC Territory as specified in this section are outside the scope of this Contract.

3. There are two types of CBTC Territory, subway and surface, as described below:

    a. Subway

        i. The Market Street and Twin Peaks subway tunnels, collectively referred to as the Market Street Subway.

        ii. The Muni Metro Turnback (MMT) section of the Market Street tunnel, consisting of the subway between Embarcadero station and the Ferry Portal to the surface at Embarcadero and Folsom Street.

        iii. Market Street Subway portals and shooflys at (former) Eureka Station, used for maintenance access only. These will be used for Maintenance Vehicle check-in only. CBTC Territory shall not extend past the tunnel portal.

        iv. The Central Subway tunnel, including tail tracks north of Chinatown station

        v. Sunset Tunnel, on the N Line between Carl St and Duboce Ave

b. Surface

i. Sections of the Muni Metro which run either on exclusive Right-of-Way (ROW), in the center of the street on semi-exclusive ROW or in the street in mixed flow traffic.

ii. Surface yards and storage tracks used for operations such as Mint Yard at Church St and Duboce Ave, and tail tracks such as at 6th and King Streets.

iii. Transition areas between the mainline and the maintenance yards as necessary to initialize the Train in the CBTC and ensure it is fit for service.

4. CBTC Territory does not include:

a. The Heritage Vehicle-only alignment in the center of the Embarcadero between Folsom Street and the Jefferson Loop, and the Jefferson Loop at Fisherman's Wharf

b. The Heritage Vehicle-only surface tracks on Market Street, including spur tracks on 17th Street and Noe St which connect these tracks to the J Line on Church.

c. The surface tracks connecting the Eureka Portals to the Heritage Vehicle-only surface tracks on Market Street.

d. Cable car tracks

e. Maintenance yards, except the test tracks at Green and MME as noted in this Section.

i. Muni Metro Division (Green)

ii. Muni Metro East (MME) (25th Street)

iii. Cameron Beach Yard (Geneva Ave) – Currently used for Heritage Vehicles and M line turnback.

2.2.3 MUNI METRO BRANCH LINES

1. The surface CBTC Territory includes the surface branches of the following Lines:

a. J Church: Balboa Park to Church & Duboce

b. K Ingleside: Balboa Park to West Portal via Ocean Avenue

c. L Taraval: Zoo to West Portal via Taraval Street

d. M Ocean View: Balboa Park to West Portal via SFSU

e. N Judah: Ocean Beach to Duboce Portal, and Ferry Portal to 6th & King

f. T Third: Sunnydale to Central Subway Bryant Portal

2.3 GEOGRAPHIC SCOPE AND DEPLOYMENT PHASES

1. Contractor shall plan the implementation of the CBTC System by Deployment Phases, as described below. Each Deployment Phase includes the activities for the Construction Final Design, Pre-Installation, Installation, Testing and Commissioning, Warranty, and Conditional Acceptance specific for that Deployment Phase, as described in Section 4.2 (Design Lifecycle). The Deployment Phases are as follows:

a. Pilot Phase: Third Street corridor from Muni Metro East yard to the Central Subway portal at 4th and Bryant, N Judah corridor from 6th & King along the Embarcadero to Ferry Portal.

b. Subway Replacement Phase: Market Street Subway & Central Subway

c. N Expansion Phase: Judah corridor from Duboce Portal to Ocean Beach, including Sunset Tunnel

d. T Expansion Phase: Third corridor from Muni Metro East yard to Sunnydale

e. K&M Expansion Phase: Ocean View and K Ingleside corridors from West Portal to Green yard

f. J Expansion Phase: Church corridor from Duboce Portal to Green Yard

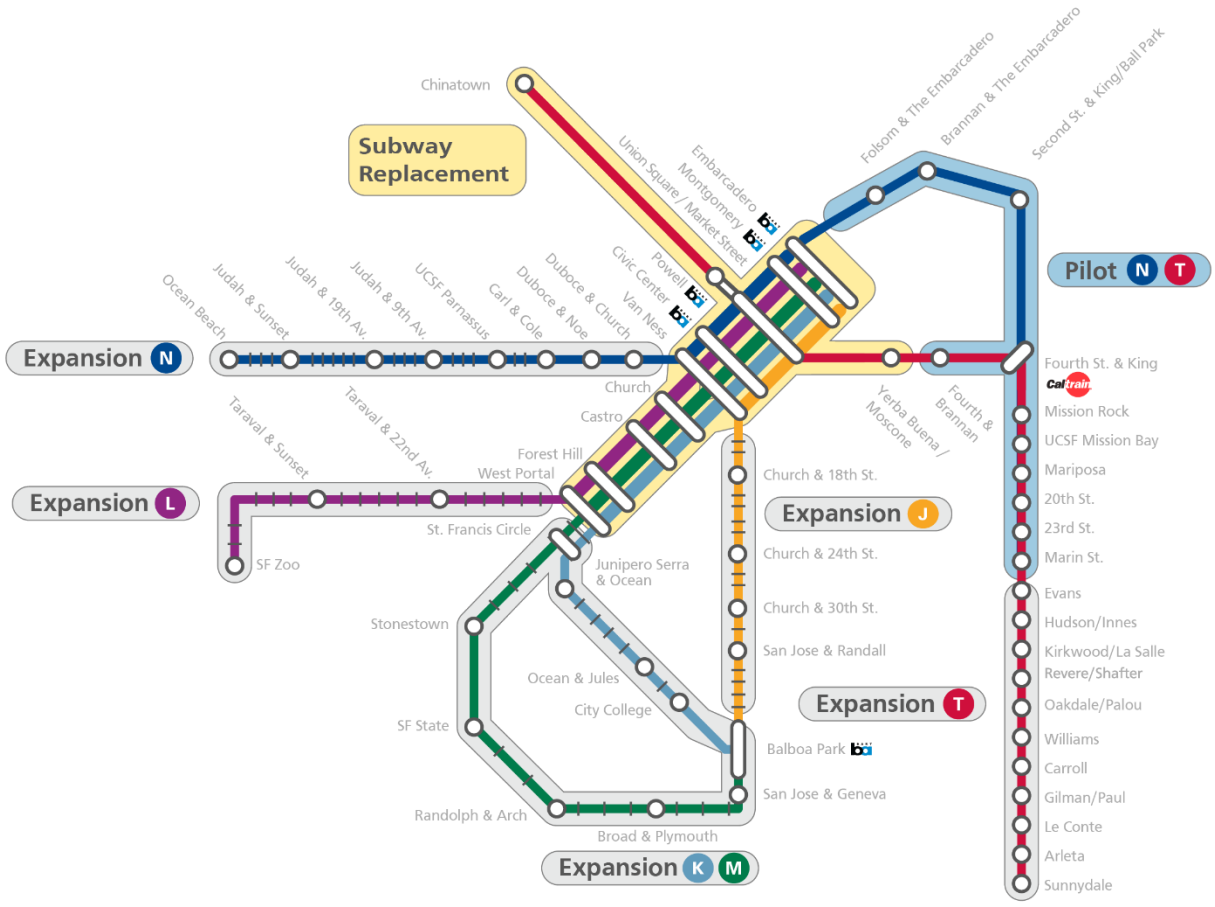
g. L Expansion Phase: Taraval corridor from West Portal to SF Zoo

2. The Contractor's responsibilities for Deployment Phase planning shall include all Contractor Work and third parties' work, including installation work.

3. Milestone completion dates for Phases and other time requirements for Project Phases, including Deployment Phases, are stated in Section 8.3.

4. The Contractor shall install a test track in the MME yard as part of the Pilot Deployment Phase and a test track in the Green yard as part of the Subway Deployment Phase, as described in Section 31.6 (Test Tracks).

Figure 2-1: Deployment Phases



2.4 CBTC Fleet including Options

1. The Muni Metro currently operates three different types of revenue Vehicles on the network:
    a. Siemens LRV4
    b. Breda LRV 2/3
    c. Heritage fleet
2. Breda LRV 2/3s are near retirement age and shall not be fitted with CBTC Equipment.

2.4.1 LRV 4 Fleet

1. This new fleet of 219 Vehicles is currently being supplied to SFMTA by Siemens. SFMTA has an option to purchase an additional 30 Vehicles by June 30, 2025.
2. Each LRV4 is 75 feet long. LRV4s are designed to operate in one, two, three and four car Consists. The CBTC System shall support any of these Vehicle Consists, starting from Subway Cutover.

3. All LRV4s currently in service are fitted with Contractor's SelTrac IS ATCS VOBC equipment for use in the subways. Contractor shall not disrupt the proper functioning of the ATCS equipment onboard LRV4s until after Subway Cutover, unless authorized by SFMTA in writing. See Section 24.8 (Migration). SFMTA may permit Contractor to disrupt the ATCS equipment on specifically authorized Vehicles so they may serve as the First Car or Test Car, as described in Section 8.3.1.3 (Onboard Equipment Fitting).

4. Contractor shall Equip all 219 LRV4 Vehicles with the CBTC System, included in the base price of this Contract.

5. Contractor shall price up to 30 additional LRV4 Equipment kits on a per-unit basis and SFMTA may exercise the option (Option 1) to purchase between 0 and 30 additional Equipment kits.

2.4.2 HERITAGE FLEET

1. The Heritage fleet is a fleet of 50 Vehicles, mainly PCC and Peter Witt cars along with some veteran San Francisco streetcars and 10 very diverse cars including rail vehicles from the UK, Japan, Italy, and Portugal. Specific Heritage Vehicles are identified in the Historic Vehicle Inventory provided in the Reference Materials with a Condition of "Revenue Car" or "Special Service," Revenue Cars are PCC and Peter Witt ("Milan") cars used in daily revenue service. Special Service cars are the other unique cars which are only used between one to six times per year as part of special events or charters.

2. Muni operates Heritage Vehicles on the surface on Market Street and along the Embarcadero, which are excluded from the CBTC Territory (see Section 2.2.2). For pull-in/pull-out to the yards, Heritage Vehicles operate in portions of CBTC Territory, including:

    a. The N Service Line trackway between Market Street and Caltrain (6th and King yard)

    b. The J Service Line from Market Street south to Balboa Park, including non-revenue and M Service Line tracks to reach Cameron Beach yard.

    c. The northern portion of the T Service Line south to 23rd and Third, including non-revenue tracks to reach the Muni Metro East yard.

3. The Contractor shall design the CBTC System so that the Heritage Vehicle fleet operates with CBTC equipped LRVs operating on the surface in the portions of CBTC Territory defined in this Section 2.4.2.

4. If special wayside Equipment is required to accommodate Contractor's solution for Heritage Vehicles, such Equipment shall be deployed in the geographic area defined for the Pilot Phase and the J Expansion Phase in Section 2.3 (Geographic Scope and Deployment Phases) only.

5. The Contractor shall design Heritage Vehicle Equipment kits to enable the functions described in these Contract Specifications for Heritage Vehicles. This design up to PDR is included in the scope of this Contract. SFMTA will review Contractor’s design solution and decide whether to exercise the option to continue the design past PDR (Option 6) and the option to purchase Heritage Vehicle Equipment kits (Option 2) during the Preliminary Design Review.

6. Heritage Vehicles shall be vitally tracked while operating in CBTC Territory provided the VOBC has position established and is communicating with the ZC.

7. If the VOBC does not have position established, the Vehicle's position shall be non-vitally tracked, even if the VOBC has failed, provided the MCG is working normally.

8. The Contractor's design shall not incorporate any Equipment installed on the axles of the Heritage Vehicle, such as speed sensors (tachometers).

9. The CBTC System shall provide all Route Setting Functions described in Section 17.5.1 and the Interlocking functions specified in Section 16.3.1.2 (Interlocking Functions) for Heritage Vehicles.

10. Equipment installations will have significant restrictions based on the unique construction and historic nature of those Heritage Vehicles.

    a. Any Equipment installed in the Heritage Vehicle shall not be visible from the passenger compartment.

    b. Exterior Equipment shall similarly be hidden from view so that visually a Heritage Vehicle with installed Equipment is indistinguishable from an unequipped Heritage Vehicle.

    c. The design of the onboard Equipment shall take into account the existing limitations of power and electrical systems of individual Heritage Vehicles.

11. SFMTA will exercise the option (Option 2) to purchase between 30 and 50 Heritage Vehicle Equipment kits for the prices stated in Appendix B, if the Contractor's design meets all requirements for Heritage Vehicles in these Specifications.

    d. When SFMTA exercises the option to purchase Heritage Vehicle Equipment kits, the Contractor shall furnish its onboard Equipment for each type of Heritage Vehicle identified in the option. The Equipment shall be fully functional and comply with the applicable restrictions. Contractor shall include all parts, installation instructions, specifications and procedures, Equipment and Materials (including Shop Materials) necessary for the installation in these kits.

    e. The Contractor shall work closely with SFMTA during the Design Phase to develop an installation plan that meets the Contract's functionality requirements while compensating for individual vehicle constraints.

    f. Contractor's technical staff shall be present on-site during installation of the first vehicle of each type identified in the purchased Options, to clarify to the SFMTA and its Installer the Contractor's installation instructions, specifications and procedures.

    g. Following installation, Contractor shall perform all testing of its Equipment on Heritage Vehicles necessary to ensure proper functionality with the CBTC System and demonstrate the requirements for Heritage Vehicles in these Contract Specifications are met.

    h. Contractor shall be available during Heritage Vehicle installation to assist in troubleshooting or to answer any questions about the Contractor's installation instructions, specifications and procedures.

    i. SFMTA, in its sole discretion, may decline to install some or all of the Special Service cars with Contractor’s Equipment. If SFMTA declines to install Contractor’s Equipment on these cars, the Contractor shall provide the SFMTA the ability to manage unequipped Special Service cars to permit their occasional operation during heritage days or other special events by MRA.

2.4.3 MAINTENANCE VEHICLES

1. SFMTA maintains a fleet of 26 hi-rail Maintenance Vehicles for use in maintenance. Contractor shall design the CBTC System so that the Maintenance Vehicles may operate in ATO Territory with CBTC equipped LRVs.

2. The Contractor shall design Maintenance Vehicle Equipment kits to enable the functions described in these Contract Specifications for Maintenance Vehicles. This design up to PDR is included in the scope of this Contract. SFMTA will review Contractor's design solution and decide whether to exercise the option to continue the design past PDR (Option 6) and the option to purchase Maintenance Vehicle Equipment kits (Option 3) during the Preliminary Design Review.

3. If special wayside Equipment is required to accommodate Contractor's solution for Maintenance Vehicles, such Equipment shall be deployed in ATO Territory only.

4. Maintenance Vehicles shall be detected and tracked as described in Section 19.3 (Vehicle Location and Speed Determination).

5. The Contractor's design shall not incorporate any equipment installed on the axles or steel wheels of the Maintenance Vehicle, such as speed sensors (tachometers).

6. Contractor shall price up to 30 Maintenance Vehicle Equipment kits on a per-unit basis and SFMTA will exercise the option (Option 3) to purchase between 0 and 30 Maintenance Vehicle Equipment kits.

7. Any Contractor-supplied Equipment shall include a power on/off switch accessible by the driver while operating the Maintenance Vehicle, or other means, so that the VOBC may be activated when the Vehicle enters CBTC Territory and deactivated when it leaves CBTC Territory as described in Section 16.3.1.1 (Entering/Exiting CBTC Territory). The Contractor may design Equipment to tie into existing Vehicle controls or activate/deactivate automatically to meet this requirement.

8. When SFMTA exercises the option to purchase Maintenance Vehicle Equipment kits, Contractor shall furnish onboard Equipment for each type of Maintenance Vehicle identified in the option which will comply with the applicable restrictions. Contractor shall furnish all parts, installation instructions, specifications and procedures, Equipment and Materials (including Shop Materials) for this installation.

9. Installation on Maintenance Vehicles may require customization of Contractor's standard installation instructions, specifications or procedures. Contractor shall work closely with SFMTA during the Design Phase to develop an installation plan that complies with the applicable restrictions and works with Contractor's design.

10. Contractor's technical staff shall be present on-site during installation of the first vehicle of each type identified in the purchased Options, to clarify to the SFMTA and its Installer the Contractor's installation instructions, specifications and procedures.

11. Contractor shall be available during Maintenance Vehicle installation to assist in troubleshooting or to answer any questions about the Contractor's installation instructions, specifications and procedures.

12. Following installation, Contractor shall perform all testing of its Equipment on Maintenance Vehicles necessary to ensure proper functioning with the CBTC System to demonstrate the requirements in this section are met.

2.5 SUPPORT OF INSTALLATION ACTIVITIES

1. Contractor shall design, develop, manufacture, factory test, site test, commission, demonstrate System performance, perform safety and security certification, and provide training for the CBTC System in accordance with the requirements indicated in the Contract.

2. The installation of the Equipment furnished by Contractor will be performed by Installers contracted by SFMTA. Contractor shall provide qualified field and engineering personnel to monitor and inspect the installation to ensure it is conducted according to the specifications in the approved System Design Documents and in accordance with Contractor's installation instructions.

3. Contractor shall assign their qualified personnel on site at each location the Installer(s) is working.

4. Contractor shall report to SFMTA any variances in installation procedure from the approved System Design Documents or installation instructions it observes.

5. Contractor shall perform all tests and inspections identified as part of the Contractor's Scope of Work in these Contract Specifications, as well as any additional tests and inspections the Contractor deems necessary to ensure System performance meets the Performance Targets committed to in the Agreement.

6. When, in the course of performing the tests and inspections described in these Contract Specifications, if Contractor finds errors or defects in installation, or other non-conforming installation work, Contractor shall report these discrepancies to the SFMTA within the times prescribed in the Project Management Plan.

7. Contractor shall attend and provide active participation in meetings, workshops and other supporting meetings with Installers as requested by SFMTA throughout the Procurement Term.

8. In support of SFMTA overall procurement and management of the installation scope, Contractor shall supply SFMTA with:

    a. Remote and on-site Support to address and resolve in-process installation and testing issues

    b. Coordination support for Equipment, schedule and other stakeholder coordination

    c. Interface documentation, installation documents/Drawings, Post Installation Check Out (PICO) procedures.

    d. All Equipment and Materials necessary to install Contractor’s System on SFMTA premises, except SFMTA Furnished Items as defined in Section 9 and SFMTA-approved Shop Materials, furnished by Installers.

9. Contractor shall perform Design Reviews with SFMTA and SFMTA’s Installers. Contractor shall successfully resolve all comments made in the Design Reviews.

10. SFMTA will receive RFIs from Installers during Equipment installation that will require SFMTA to obtain information from Contractor. The SFMTA will issue Installation RFIs to Contractor, and Contractor shall respond within 10 Days of receiving an Installation RFI from SFMTA, unless SFMTA grants an extension of time. Contractor shall be liable for Installers’ claims against SFMTA arising from Contractor’s failure to timely respond to Installation RFIs.

11. Contractor shall meet with the SFMTA and its Installers to review all Contractor-provided installation process and procedures prior to Equipment installation, and as needed during the installation, as described in Section 4.2.6 (Delivery and Installation).

12. Contractor shall provide installation Quality Control oversight and expert instructions prior to and during Equipment installation as described in Section 5 (Quality Assurance and Quality Control). The Installer shall perform the installation.

13. Contractor shall inspect the installed works and verify that the Equipment was installed to the Contractor's specifications. The Contractor may be present for any Installer-performed tests. Witnessing Installer-performed tests does not relieve the Contractor of the responsibility for discovering defects in installation.

14. Contractor shall document all defects in installation found during its inspections, observations, or testing and report them to SFMTA.

15. Contractor shall submit to SFMTA documentation of inspection and testing to support SFMTA Acceptance of Installer works.

16. Shop Materials are common installation materials necessary to install the CBTC Equipment that Installers can readily obtain from commercial sources, which include conduit, wiring, cabling, cable trays, connectors, utility boxes, waterproofing materials, wood, structural steel and support materials. As part of Construction Final Design Review for each Phase, Contractor shall include a list of all Shop Materials necessary to complete the Installation Activities during that Phase, including estimates of quantities needed and any Contractor specifications regarding brand, quality, material, etc.

17. SFMTA will review and approve the Shop Materials list. Installers will provide Shop Materials on the SFMTA-approved list. Any Materials not on the SFMTA-approved Shop Materials list shall be provided by Contractor.

18. Installers shall use any brand, quality or type of Shop Materials which meets the Contractor's specifications as provided for in this Section. If a System failure was due to the failure of Shop Materials, Contractor remains responsible for System Performance according to the terms in this Agreement, provided the Shop Materials used were in accordance with Contractor's specifications. Contractor may inspect Shop Materials provided by Installers and reject individual Shop Materials for quality according to its QA program. Contractor waives all claims arising from the variance of quality of Shop Materials meeting Contractor's specifications.

2.6 SYSTEM INTEGRATION SERVICES

1. Contractor shall develop a System Integration Management Plan [CDRL], as specified in Section 4, to coordinate design, development, delivery, integration, testing and Commissioning of the CBTC System and associated elements through approved Deployment Phases and finally as a whole fully verified and validated CBTC System.

2. The System Integration Management Plan shall describe in detail all CBTC System integration requirements, data flow requirements and include all associated diagrams and designs.

3. Contractor shall describe the interfaces between all Equipment components and between those components and the environment within which they operate, including any APIs required for the CBTC System, in the System Integration Management Plan.

4. Contractor and SFMTA will confer and determine which interfaces and API Contractor shall develop and manage and which interfaces SFMTA shall develop and manage. Generally, Contractor shall be responsible for ensuring the CBTC System exports all data needed by Third-Party Systems and processes any data it requires from Third-Party Systems to meet the requirements stated in these Specifications, and SFMTA will be responsible for ensuring the data is formatted properly according to Interface Control Documents provided by Contractor and Third-Party Systems, stored in the correct databases, and transmitted to the correct endpoints. SFMTA will develop its own middleware for this purpose if necessary.

5. SFMTA will build and manage the integration between the CBTC System and Third-Party Systems. Contractor shall collaborate and support these efforts to ensure all requirements are met.

6. Contractor shall build and manage the on-board interfaces between its System and Vehicle systems.

7. Contractor shall perform all necessary surveys including Electromagnetic Interference (EMI), communications, trackside Hardware placement and environmental studies, analysis, and tests to support design, installation, testing, Commissioning, and California Public Utilities Commission (CPUC) approval into service of the CBTC System.

8. Contractor shall submit and implement an Interface Management Plan and accompanying Interface Control Documents [CDRL], as specified in Sections 4 and 28, for all external and internal interfaces.

    a. Contractor and SFMTA will confer and determine the Third-Party Systems to be interfaced with, and the type of interface to be used, as part of the design process.

    b. Where the CBTC System is required to interface to a Third-Party System, Contractor shall define and produce Interface Control Documents and all other necessary development to ensure proper management of that interface in coordination with SFMTA and Third-Party Systems.

    c. SFMTA shall have approval for all required modification or introductions to SFMTA and Third-Party Systems as specified in Section 28 (Interface Requirements Specifications).

    d. Where approval of a modification requested by Contractor cannot be accommodated by SFMTA, Contractor shall propose alternative designs that will meet the requirements of the Specifications without additional cost to SFMTA.

    e. Contractor shall support SFMTA in SFMTA management of all interfaces to Third-Party Systems.

9. Contractor shall design and conduct testing of its internal CBTC and external CBTC interfaces to Third-Party Systems to verify and validate the System meets all applicable requirements.

10. Contractor shall be responsible for integrating the CBTC System with the Vehicles.

    a. Contractor shall modify the design the CBTC System as necessary for application to SFMTA Vehicles, including those used for Revenue Service and for maintenance activities, as further specified in the Contract.

    b. Contractor shall submit a design that requires the least amount of impact and changes to Vehicles. SFMTA shall have final approval for all required modifications to the Vehicles.

    c. Where approval of a modification requested by Contractor cannot be accommodated by SFMTA, Contractor shall propose alternative designs that meet the requirements of the Specifications without additional cost to SFMTA.

2.7 CBTC EQUIPMENT

1. Contractor shall Furnish all CBTC Equipment.

2. Furnished Equipment shall be new and in good condition.

3. As part of the System Design Documents, Contractor shall describe to SFMTA how the Furnished Equipment has been successfully used as part of other transit agencies' CBTC systems.

2.8 NON-CBTC EQUIPMENT

1. Contractor shall provide Uninterruptible Power Supply (UPS) Equipment as specified in Section 16.2.3.

2. Contractor shall evaluate the current conditions of any location where Contractor provided Equipment will be permanently installed and report to SFMTA whether any modifications to the facility or cabinet's Heating, Ventilation & Air Conditioning (HVAC), cabling pathways, power supplies, and other civil, mechanical, plumbing, communications, and electrical systems are required to support the CBTC System as per the requirements of this Contract.

    a. If Contractor reports that modifications are required to any of SFMTA facilities or cabinets, Contractor shall include in the report its environmental, physical, communication, power, or other such requirements to accommodate its CBTC Equipment in the facility. SFMTA will prepare designs for modifications of its facilities and cabinets.

    b. Contractor shall review any SFMTA facility or cabinet designs intended to accommodate its CBTC Equipment and confirm that the designs meet its specifications.

    c. Where a modification requested by Contractor cannot be accommodated by SFMTA, Contractor without additional cost to SFMTA shall propose alternative System designs, such as relocating CBTC Equipment, that take into account the requirements of that equipment and the limitations of SFMTA's existing facilities and cabinets.

    d. Contractor may propose locating CBTC Equipment in a new location, such as a new cabinet. Contractor shall develop designs and furnish Materials for any new locations it proposes.

2.9 EQUIPMENT ROOMS

1. Equipment may be installed only in the following locations:

    a. Transportation Management Center theater and Data Center (primary Control Center)

    b. Lenox Operations Control Center theater and Data Center (backup Control Center)

    c. UMS Data Center located in Union Square / Market Street (UMS) Station

    d. Temporary Control Center at 1 S. Van Ness 8th Floor

    e. Muni Metro East rail yard

    f. Muni Metro (Green) rail yard

    g. Wayside Technical Rooms

    h. Subway Equipment Rooms

    i. Wayside Equipment Cabinets (freestanding outdoor cabinets near ROW)

j. SFMTA Data Center and Network Rooms

k. Along the SFMTA's Right of Way (ROW), including in the trackway and on designated poles adjacent to the ROW. SFMTA will designate suitable locations along the ROW during design.

2. Contractor shall survey these locations and produce plans for SFMTA showing where its Equipment will be installed.

3. Contractor shall notify SFMTA if the location or space is not sufficient to accommodate the Equipment to be installed.

4. Where necessary for the CBTC System or during the Migration to the CBTC System, SFMTA may provide additional or alternate accommodations for Equipment where existing Train Control Room space is not sufficient to accommodate any necessary temporary Equipment. Contractor shall provide temporary racks, power supplies or other materials or housings to store temporary Equipment.

2.10 SCOPE SPLIT

1. Contractor shall provide the CBTC System, but elements of the System will be installed by Installers contracted to SFMTA. The below table 2-1 summarizes the work to be performed by Contractor and by Installers:

Table 2-3 Project Contracts Table

Contract	Firm	Scope
System Procurement and System Support	Contractor	Design, Furnish Equipment and Software, construction/installation oversight & management, QA/QC, test and commission the CBTC System as specified in this Contract. Provide technical support, parts, training, Software updates, testing as specified in this Contract
System Installation	One or more Installers under separate contracts with SFMTA	Install Central Equipment, wayside Equipment, communication/network Equipment and perform any other System installation work requiring a California contractor's license
LRV4 Installation	Separate Installer under separate contract with SFMTA	Install Contractor's onboard Equipment on LRV4 vehicles
Technical Services	Consultant under separate contract with SFMTA	Augment SFMTA engineering team, assist SFMTA with Project oversight

2. The following Table 2-2 RACI Chart summarizes the roles and responsibilities of the Contractor, the SFMTA, and its Installers in delivering the Project in more detail. The following definitions are used:

a. Responsible (R): The entity that is responsible for performing the work, process, or task assignment, or providing the resources.

b. Accountable (A): The entity that is answerable for the correct and thorough completion of the deliverable or task, the one who ensures the prerequisites of the task are met and who delegates the work to those responsible.

c. Consulted (C): The entity whose opinions are sought in relation to the work being performed and who provides feedback on submittals, drafts or the work itself. Involved in two-way communication with Responsible and Accountable entities.

d. Informed (I): The entity that is kept up-to-date on progress, who receive a copy of the work or deliverable, and with whom there is just one-way communication with Responsible and Accountable entities.

Table 2-2 RACI Chart

Responsibility	Contractor	Installer	SFMTA
Installation			
Provide Security of Installation Sites	I	I	A/R
Provide Office Facilities	I	I	A/R
Manage Facilities (identified in Section 9.3)	C	I	A/R
Perform Installation Activities (as defined in Section 2.5)	C	R	A
Perform On-site Supervision of Installation Activities	R	I	A
Develop Installation Instructions and Design Documents	A/R	I	C
Provide Equipment and Installation Materials (except Shop Materials)	A/R	I	C
Provide Shop Materials	C	R	A
Provide SFMTA Furnished Items identified in Section 9.3	C	I	A/R
Provide Deployment-specific Artifacts for preparation of Safety Case	A/R	I	C
Perform Independent Quality Assurance of Installed Works (as described in Sections 5.6.3 and 8.5.1)	R	C	A/R
Provide Jobsite Safety	R	R	A/R
Prepare Installation SOW	R	I	A/R
Prepare Installer Bid Package and Contracting	C	I	A/R
Implement Hardware Modifications On-site	A	R	C
Provide As-Built Drawings	C	R	A
Testing			

Responsibility	Contractor	Installer	SFMTA
Prepare PICO Testing Plans	A/R	I	C
Provide PICO Test Procedures	A/R	I	C
Conduct Vehicle Post Installation Check-Out (PICO) Tests	A/R	I	C
Conduct Wayside Post Installation Check-Out (PICO) Tests	C	R	A
Prepare PICO Test Reports	I	R	A
Prepare PICO Certificates	C	R	A
Review PICO Results	A/R	I	C
Conduct Vehicle Acceptance Testing (defined in Section 31.7.4)	A/R	I	C
Conduct Site Acceptance Testing (SAT)	A/R	I	C
Prepare SAT Test Results and Certifications	A/R	I	C
Perform Procedure Verification Testing (defined in Section 31.7.7)	A/R		C
Perform System Stress Testing (defined in Section 31.7.8)	A/R		C
Perform SFMTA-Directed Testing (defined in Section 31.8)	C		A/R
Provide Operations Staff for all Dynamic Testing (as referenced in Section 9.4)	C		A/R
Integration			
Perform Vehicle Integration	A/R	R	C
Perform System Integration (with Third Party Systems)	R		A/R
Perform Integration with Wayside Equipment	A	R	C

3. If any conflicts exist between Table 2-2 and any other requirements in these Contract Specifications, the requirements, and not the table, shall prevail.

4. As part of its CDR submission, Contractor shall develop a detailed Scope Split [CDRL] document that describes the roles, responsibility, scope, and work location of all stakeholders, subcontractors, O&M Service providers and other third parties, including City, SFMTA and Installers, required for the successful completion of this Project.

5. The Scope Split document shall clearly detail the required contribution required throughout the Project design and Deployment Phases.

6. Contractor shall develop the Scope Split document to maintain clear management of the scopes such that Project execution through to Final Acceptance is achieved consistent with Contract requirements.

2.11 SUMMARY OF WORK CDRLS

Table 2-3 Work and Scope Split CDRL Table

CDRL #	CDRL Title
2.1	Scope Split

3 PROJECT MANAGEMENT

3.1 PURPOSE

1. This Section describes Contractor's project management obligations, including developing the plans, processes, and procedures to deliver the Project on schedule meeting all Contract requirements.
2. In collaboration with SFMTA, Contractor shall develop project management documents, listed in Section 3.11 (Project Management CDRLs), that provide guidance and control for the Project's execution and will facilitate early identification of potential areas of risk or need for changes to the Project.
3. Contractor shall submit the project management documents described in this Section to the SFMTA for review.
4. Contractor shall follow the practices and procedures contained in the approved project management documents.
5. This Project will be a catalyst for organizational change to SFMTA's operations. In the project management documents, Contractor shall recommend best practices for working with its CBTC System based on its experience with other projects. Contractor shall note where its recommended best practices differ from existing SFMTA operational or project management practices. SFMTA may require edits to the project management documents which differ from Contractor's recommendation where necessary to accommodate its organizational change.

3.2 PROJECT MANAGEMENT STRUCTURE

3.2.1 PROJECT MOBILIZATION

1. Upon receipt of Notice to Proceed (NTP), Contractor shall commence Contract mobilization activities which include, but are not limited to, the following:
    a. Relocation of Contractor's project team, including Key Personnel, to San Francisco as Contractor deems necessary to satisfy performance requirements or as specifically required by the Agreement.
    b. Initiate Contractor's provision of an On-Site Trailer at the MME Yard. Contractor shall use this On-Site Trailer as office space for Contractor's staff during On-Board Installation, and it shall accommodate space for up to 8 SFMTA fleet engineers / Vehicle technicians.
    c. Confirm location of warehouse space in the San Francisco Bay Area sufficient for Spare Parts inventory in accordance with Section 13.4 (Spare Parts Handling) and to support Project Deployment as required in Section 27.11 (Equipment Handling).
    d. Contractor shall submit an Office and Warehouse Details document [CDRL] to SFMTA for SFMTA approval within 30 Days following NTP.
    e. The Office and Warehouse Details document shall describe:
        i. The location and space layout of all local offices
        ii. The location and space layout for all material storage spaces Contractor intends to use during the Procurement Term, including any temporary staging areas.

2. While they are working on the Project, Contractor shall assign its Key Personnel and other locally-based project team members to work in the shared project office furnished by SFMTA. See Section 9.4 (Temporary Furnished Items).

3. Contractor shall submit the Project Organization and Staffing Plan [CDRL] 30 days after NTP.

4. Contractor shall mobilize Contractor team members as identified in the Organization and Staffing Plan.

5. Contractor shall maintain the Project Organization and Staffing Plan so that it always reflects the current composition of Contractor's team.

6. Contractor shall distribute revisions and updates to the Project Organization and Staffing Plan as revisions occur through the Procurement Term.

7. The Organization and Staffing Plan shall list all staff, including any Subcontractor staff and include:

    a. Hierarchical organization chart

    b. Staff Contact List containing:

        i. Staff Name

        ii. Staff Role

        iii. Contact Information including names, phone numbers, and email addresses

        iv. Work Location

    c. A specific and separate identification of following Key Personnel. Replacements of Key Personnel are subject to Section 5.5.2 of the Agreement.

        i. Project Manager –10 years experience in similar capacity of major CBTC Projects

        ii. Lead Engineer – 8 years experience in similar capacity of major CBTC Projects

        iii. Lead Vehicle Engineer

        iv. System Assurance Manager

        v. Quality Assurance Manager

        vi. Test and Commissioning Lead – 8 years experience in similar capacity of major CBTC Projects

        vii. Safety and Security Manager

        viii. Technical Support Lead

    d. Qualifications, job responsibilities and functional relationships of Key Personnel and other Contractor and Subcontractor staff.

8. Within 15 Days following NTP, Contractor shall submit the Interim Project Schedule describing the Work it will perform for the following one hundred and twenty (120) days.

9. Contractor shall prepare and submit other Project Management CDRLs as per the schedule set out in Section 35.2 (CDRL Schedule).

3.2.2 CONCEPT OF OPERATIONS AND MAINTENANCE

1. SFMTA has included a draft Concept of Operations and Maintenance in the Reference Materials that provides an overview of SFMTA's current rail operations, organization and facilities. It also includes sections describing SFMTA's expectations for the improvements the new CBTC System will bring to operations, as well as anticipated changes of operational and maintenance rules, processes, and procedures.

2. Contractor shall develop and submit a CBTC Concept of Operations and Maintenance [CDRL] using the SFMTA-provided draft Concept of Operations and Maintenance document as a base document.

3. Contractor shall develop the CBTC Concept of Operations and Maintenance to:

    a. Reflect the operational and maintenance concepts and requirements specific to Contractor's System design.

    b. Recommend changes to SFMTA operations or maintenance policies, practices or procedures to accommodate CBTC System requirements, take advantage of new features and functionality included in the CBTC System, or incorporate Contractor's recommended best practices for CBTC System operation or maintenance.

    c. Develop use cases based on the functional requirements contained in these Specifications and the operational and maintenance policies and procedures described in the CBTC Concept of Operations and Maintenance. SFMTA may execute the use cases in verification testing during acceptance testing to be conducted by SFMTA as provided for in Section 31.8.

4. Contractor shall review its Concept of Operations and Maintenance with the SFMTA.

    a. As part of the review, Contractor shall describe any differences between Contractor's submitted Concept of Operations and Maintenance and the draft Concept of Operations and Maintenance provided by SFMTA.

    b. Contractor shall modify the final Concept of Operations and Maintenance document in response to SFMTA comments and feedback.

3.2.3 PROJECT MANAGEMENT PLAN

1. The Project Management Plan governs the execution of the entire Project, including SFMTA Project staff. SFMTA has included a draft Project Management Plan containing some of the above sections in the Reference Materials. This draft contains SFMTA-specific project management policies and procedures. Contractor shall base its Project Management Plan on this draft and shall not remove sections or clauses which do not apply to Contractor.

2. Contractor shall develop and submit a Project Management Plan (PMP) [CDRL].

3. The PMP shall conform to the Project Management Plan Outline per the Federal Transit Administration (FTA)'s Project and Construction Management Guidelines.

4. The PMP shall contain:

    a. A definition and detailed description of Project implementation, monitoring and control, and an outline of the Project scope, goals, timelines and Deliverables.

    b. A description of the Project Scope of Work, identifying Contractor's and Subcontractors' Work. The description should also identify work that Contractor expects SFMTA, Installers,

and other third parties to perform. The description shall include Project quality, safety, design, development, procurement, delivery, installation, testing, integration, Migration, and handover for Final Acceptance.

c. A list of all entities (Contractor, Subcontractors, SFMTA, City, Installers, other third parties) who have a role in the Project, and a brief description of their role.

d. A description of the Contractor's roles and responsibilities with respect to Installers.

e. A Project Work Breakdown Structure (WBS) to be used as an organizational document forming the structure of the Project Schedule. The WBS shall incorporate the Project Milestones described in Appendix C of the Agreement.

f. The Project Organization and Staffing Plan. See Section 3.2.1 (Project Mobilization) for details. Contractor shall ensure the Project Organization and Staffing Plan contained in the PMP is kept current.

g. A description of Project controls and monitoring approaches Contractor shall implement, including:

   i. Team/resource management and training

   ii. Subcontractor management

   iii. Budget/cost/invoicing management and control

   iv. SFMTA/Contractor letter correspondence process

h. A schedule development, review and management process that provides transparency between the planned and actual work progress, meets the requirements in Section 3.2.4, integrates risk and Change Control Processes, as described in Section 15, and provides guidelines for metrics and other summary reporting as may be needed by various funding agencies and/or stakeholders.

i. A Project Meeting and Reporting Plan including distribution and content objectives for each meeting and report. This plan shall be reviewed and updated on a regular basis.

j. A description of the Quality Assurance and Quality Control program including requirements for key inspections, Milestones, hold points, and integration requirements. See Section 5 (Quality Assurance and Quality Control) for more details.

k. The Change Control Process which will be used for all changes throughout the term of the Agreement, as specified in Section 15 (Change Control Procedures).

l. A risk and opportunity management process and Contractor's development of a common risk register that will be reviewed by SFMTA throughout the life of the Project. Risk management requirements are further described in Section 3.3 (Risk Management).

m. Transition plans between Phases, including transitions from each Deployment Phase to Acceptance, to warranty, to long-term Support.

n. A description of the Final Acceptance process including how Contractor will demonstrate all Contract requirements have been met and all outstanding/punchlist items have been closed prior to SFMTA Final Acceptance. This Final Acceptance process shall only apply to the final Deployment Phase completion. See Section 8 (Deployment, Migration and Acceptance) for more details.

o. A Project retrospective process to be conducted after each Milestone, as further described in this Section 3.2.3.

p. Office and administrative procedures and tools. These procedures and tools shall include methods, processes and flow charts to show the development, delivery and Acceptance of the Project Deliverables.

q. A description of Project work locations, including the specialization and unique focus of each work site, and the interaction between work sites.

r. A Cutover and Migration plan for both Vehicles and wayside equipment. See Section 8 (Deployment, Migration and Acceptance) for more details.

s. Describe the development of the Contract Data Requirements List (CDRL) and its review process. This review process shall include the methods for management of comments, Configuration control and reporting.

t. Describe communication, decision making, and conflict resolution management activities and processes.

u. A Disaster Recovery Plan which includes a list of foreseeable disasters (e.g. earthquakes, flooding, pandemic, interruption in Services), the steps necessary to be taken to restore the Services provided by Contractor and to recover the Project to the state that existed just prior to the start of the disaster, and the disaster recovery services Contractor will provide to meet the plan's objectives.

5. SFMTA, in reviewing the Project Management Plan, may make edits to these methods, processes and procedures.

6. Contractor shall review the Project Management Plan with SFMTA on at least a yearly basis.

7. After completion of each Phase; Contractor shall update the PMP to reflect any lessons learned on the Project and to incorporate any revised practices arising from those lessons learned.

8. Contractor shall submit the Project Management Plan for SFMTA approval no later than 30 Days after NTP.

9. SFMTA may audit Contractor's adherence to the Project Management Plan including the effectiveness of Contractor's processes and procedures as it relates to Project performance. Contractor shall revise and make any corrective actions based on this SFMTA audit.

10. Contractor shall outline the Project retrospective process to encourage continuous updates of lessons learned during implementation as the Project moves forward.

    a. These lessons learned shall be used to support team understanding of issues which come up during the Project.

    b. Contractor shall design the Project retrospective process to develop actionable changes to project management documents, policies, processes and procedures to incorporate lessons learned from these retrospectives.

11. Contractor shall implement the office procedures and tools described in the PMP to provide clear and controlled interactions among all parties throughout all Phases of the Project.

3.2.4 SCHEDULES

1. Contractor shall develop and maintain the following schedules:

    a. The Baseline Schedule. The Baseline Schedule is the original schedule negotiated between the Parties included in Appendix D to the Agreement at the time the Contract is signed. It cannot be changed.

    b. The Interim Project Schedule (See Section 3.2.4.1) is a temporary working schedule to be used before a Project Schedule has been approved.

    c. The Contract Schedule is contained in Appendix D to the Agreement. It is the official schedule and can only be modified through a Change Order.

    d. The Milestone Schedule is contained in Appendix C to the Agreement and associates specific dates with payment Milestones. The Milestone Schedule is the only schedule used to calculate Liquidated Damages for Project Delays (See Section 5.18.10 of the Agreement) and can only be modified through a Change Order.

    e. The Project Schedule (See Section 3.2.4.2) is a working schedule that represents Contractor's best forecast of when activities will start and end.

    f. The Monthly Progress Schedule (See Section 3.6.2) is a backward-looking schedule report which details all the Work completed in the previous month.

    g. The Four Week Schedule (See Section 3.6.2) is a weekly schedule report which contains the Work completed in the previous week plus the next three weeks of the Project Schedule.

    h. The Recovery Schedule (See Section 3.6.2) is a temporary schedule generated when the project is behind schedule, showing an accelerated version of the Project Schedule necessary to resynchronize the Project Schedule with the Contract Schedule.

    i. The Time Impact Evaluation Schedule (See Section 3.6.2) is a schedule report generated when evaluating a Change Order or Contract Modification.

2. Contractor shall develop schedules using the Critical Path Method (CPM) and show:

    a. A critical path to all Milestones described in Appendix C to the Agreement.

    b. Activities that develop, submit and review all CDRLs.

    c. Quality related hold points and review periods.

    d. Activities for procurement, fabrication, testing and delivery of all Materials

    e. Cost loading to allow for performance and Earned Value reporting

3. Contractor shall use Microsoft Project to develop and deliver schedules to SFMTA. Contractor may use an alternate schedule tool upon request and approval by SFMTA.

4. All schedules shall include:

    a. A narrative report that describes the basic assumptions underlying the schedule for productivity and durations, design logic, manufacturing, installation, testing, Commissioning and Final Acceptance

    b. A detail analysis of all critical paths

c. Details of all schedule fields such as calendars and non-work Days, constraints, lags

5. Schedules and subsequent schedule updates shall:

   a. Include all Work (and show all tasks and activities) required to complete the Milestone(s) and Project.

   b. Include all activities needed to complete the Project and obtain SFMTA Final Acceptance, including activities to be performed by Installers. Final Acceptance activities are specified in Section 8.3.1.4 (Final Acceptance).

   c. Assign Project costs to activities to support Contractor's earned value methodology.

   d. Assign anticipated resources required for Installers.

   e. State all bases of estimation for Installers' scopes of work based upon reasonable staffing and production expectations.

   f. Include activities for subsystem and System Software development, delivery and testing, Vehicle testing, factory tests, site acceptance tests, delivery of Equipment and Materials, and Acceptance of Vehicles. Schedule for testing activities shall include sufficient time to remedy, re-test, and re-release Software.

   g. Identify, for each subsystem, external Milestones/dependencies for receipt of the necessary information, Materials, production, tests, pre-delivery inspection, or delivery of the subsystem to Contractor.

   h. Identify SFMTA Furnished Items necessary to enable and facilitate the delivery of the CBTC System and the dates Contractor has assumed SFMTA will make SFMTA Furnished Items available to the Project in order to meet the schedule.

   i. Be the basis for evaluating Contract progress and time extension requests (and claims).

   j. Include Subcontractors' activities and equipment procurement.

   k. Meet the requirements for access, sequencing, construction staging, and delivery of SFMTA-furnished materials.

6. The WBS structure from the PMP shall be used in the Project Schedule.

7. The activities and durations for all installation scope will initially be estimated by Contractor and agreed between SFMTA, Contractor and Installers prior to Installers beginning their work.

8. Any inaccuracy of the schedule or failure of the schedule to include any element of the Project Work shall not relieve Contractor from responsibility for performing the Work in accordance with the Contract requirements.

9. Contractor shall not update or modify the Contract Schedule after without a Change Order directing that such changes be made. Modifications of the Contract Schedule do not change the Baseline Schedule.

10. The Milestone Schedule contained in Appendix C to the Agreement shall not be modified, except as specified in a Change Order agreed to by both Parties. SFMTA will consider proposed changes to the Milestone Schedule if delays outside of Contractor's control cause the completion dates for any of the Milestones to differ from the Milestone Schedule.

3.2.4.1 INTERIM PROJECT SCHEDULE

1. Within fifteen (15) Days following NTP, Contractor shall submit to SFMTA an Interim Project Schedule [CDRL], covering Work/activities to be performed during the first 120 Days following NTP.

2. The Interim Project Schedule shall be structured according to the Project Work Breakdown Structure stated in the PMP. The first 120 Days of the Baseline Schedule may be used to create the Interim Project Schedule.

3. The Interim Project Schedule shall include all Deliverables and Milestones during the first 120 Days following NTP.

4. The activities described in the Interim Schedule shall be carried over to the Project Schedule.

3.2.4.2 PROJECT SCHEDULE

1. Contractor shall submit a proposed Project Schedule [CDRL] to SFMTA for review and approval no later than ninety (90) Days after NTP.

2. Contractor shall submit the proposed Project Schedule with a narrative that describes the implementation concepts, assumptions, constraints, and other relevant details that provide a greater understanding of Contractor's approach to its performance of the Work schedule.

    a. In the narrative, Contractor shall describe any differences between the proposed Project Schedule and the Baseline Schedule.

3. The Project Schedule shall include all Project activities, clearly showing the sequence and interdependencies of the Project Work. SFMTA may request additional activities be added.

4. Contractor shall develop the Project Schedule, divided into Phases as specified in Section 8.3 (Project Phases). Project-wide activities are covered in the first three Phases, and Deployment Phases are incremental closed loop schedules. Each Deployment Phase begins at the completion of the preceding Deployment Phase's Construction Final Design Period.

    a. The Pilot Phase and Subway Replacement Phase shall end at the same time, upon Conditional Acceptance of both Phases together.

    b. The Pilot and Subway Replacement Phases share the same Warranty Period.

    c. Contractor shall include Conditional Acceptance activities in each Phase's schedule.

    d. Contractor shall show the Warranty Period in each Phase schedule.

    e. Phases may be started early to accommodate procurement of long lead items needed for that Phase, to ensure those items are delivered before installation.

    f. Contractor shall incorporate Deployment and Migration activities as specified in Section 8 (Deployment, Migration, and Acceptance) into each Phase schedule.

5. Contractor shall include Design Life Cycle Milestones, gates and Design Reviews in all Phase schedules. See Section 4.2 (Design Life Cycle) for more details.

6. Contractor shall include the Initial and Final Reliability, Availability, Maintainability (RAM) Demonstration activities in the Contract Schedule.

7. Contractor shall show Final Acceptance as the final Milestone associated with the last Acceptance activity by SFMTA.

8. In developing the Project Schedule, Contractor will need to make assumptions about aspects of the Project outside of its control, such as the time Installers and other third parties identified in the PMP will require to perform their work, as well as the availability of SFMTA tracks, tunnels, facilities, personnel and other assets. When developing the Project Schedule:

    a. Contractor shall incorporate the schedule impact of SFMTA processes described in the SFMTA Track and Tunnel Access Procedures set out in Appendix J to the Agreement, and the requirements for obtaining SFMTA Furnished Items as provided in Section 9.

    b. As part of its Project Schedule submission, Contractor shall unambiguously state all assumptions it makes concerning the performance of Installers and other third parties, and the availability of SFMTA tracks, tunnels, facilities, personnel and other assets needed for Contractor to perform the Work.

    c. Contractor shall review its assumptions with SFMTA prior to submitting the Project Schedule for approval. Contractor shall amend its assumptions as directed by SFMTA.

9. Contractor is responsible for all logic and duration estimations. Contractor shall correct any inaccurate information or flaws in logic shown in the Project Schedule that may lead to inaccurate time extension analyses or conclusions at Contractor cost. The SFMTA may assess Liquidated Damages for Project Delays, as described in Section 5.18.10 (Liquidated Damages for Project Delays) of the Agreement, if these corrections delay the completion of any of the Milestones past the dates provided in the Milestone Schedule in Appendix C to the Agreement.

10. Contractor shall maintain the Project Schedule to reflect the latest information, such as the duration of activities or updated completion dates, as soon as Contractor knows they will differ from estimates.

    a. Contractor shall review the Project Schedule with SFMTA at each Monthly Progress Meeting.

    b. Contractor shall resubmit the Project Schedule for SFMTA approval each time changes are made.

    c. Contractor shall update the Project Schedule based on direction from SFMTA or new information from Installers.

    d. Contractor shall periodically review the Project Schedule with SFMTA.

    e. Contractor shall clearly indicate the effective date and version of the Project Schedule so it is clear which approved version of the Project Schedule is being referenced.

11. Contractor shall notify SFMTA when its projected completion dates for any of the Milestones differs from the Milestone Schedule contained in Appendix C to the Agreement. SFMTA may assess Liquidated Damages for Project Delays, as provided in Section 5.18.10 (Liquidated Damages for Project Delays) of the Agreement.

3.3 RISK MANAGEMENT

1. Contractor shall develop, implement and actively manage a rigorous Risk Management Process, composed of risk identification, analysis, and mitigation, activities through the completion of the Procurement Term. Risks shall be tracked in a risk register and regularly updated through risk review meetings. Contractor shall engage SFMTA, Installers and third parties identified in the PMP in this process.

2. Contractor shall include a Risk Management Process in the PMP that:

    a. Describes risk management organization including the Parties' roles and responsibilities.

    b. Describes the process to identify, assess, quantify, and manage risks and opportunities.

    c. Identifies the frequency of risk management reviews.

    d. Identifies key participants.

    e. Assesses and quantifies the probability and impact of each risk with respect to each Project Phase using a matrix similar to that shown in Table 3-1.

Table 3-4: Sample Risk Impact Assessment

Likelihood \ Impact	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	Moderate	High	High
Possible	Low	Low	Moderate	Moderate	High
Unlikely	Low	Low	Moderate	Moderate	Moderate
Very Unlikely	Low	Low	Low	Moderate	Moderate

    f. Identifies mitigation methods.

    g. Describes risk categorization.

    h. Describes the risk register.

    i. Describes risk monitoring approaches.

    j. Describes risk closure process.

    k. Describes a process for managing the risks associated with opportunities that come up during the course of the Project.

3. Contractor shall include the risk register in the Monthly Progress Report.

3.4 PROJECT MEETINGS

1. Contractor shall conduct regular internal team meetings.

2. Contractor shall also support external meetings with Project stakeholders including:

    a. SFMTA operations and maintenance staff not on the Project team but who will be affected ("Internal Stakeholders").

    b. SFMTA management and executives.

    c. Other government agencies, who may be funding partners or regulatory agencies.

d. The SFMTA Board, the San Francisco Board of Supervisors and other elected officials with oversight authority over the SFMTA.

e. Citizen's Advisory Committees, composed of members of the public appointed to review SFMTA decisions and advise the SFMTA Board.

f. Other public stakeholder groups, such as transit advocacy organizations, business groups, community groups.

3. The meetings shown in Table 3-2 shall be conducted with SFMTA.

Table 3-5: Project Meetings

Meeting	Frequency
Initial Project Conference	One Time
Progress Meeting	Monthly, Mid-Month
Safety & Security Meeting	Monthly and As Needed
Weekly Status Meeting	Weekly
Working Group workshops	As Needed
Risk and Opportunities Assessment Meeting	Semi-Annually
Project Management Review Meeting	Annual
Failure Review Board Meeting	Monthly once testing begins
Partnering Meeting	Annual

4. Contractor shall schedule and hold an Initial Project Conference in SFMTA offices within seven (7) Days following NTP (or as agreed with SFMTA Project Manager) to introduce the SFMTA Project Manager and other SFMTA staff to their counterparts in Contractor's organization, and to establish lines of communication. All Key Personnel shall attend the Initial Project Conference.

5. Contractor shall schedule and hold a Monthly Progress Meeting for the duration of the Procurement Term with SFMTA and Contractor's Project Manager, Scheduler, Site Manager, Lead System Engineer, Quality, and others as requested by SFMTA Project Manager. The purpose of the Monthly Progress Meeting is to review the Monthly Progress Report submittal, including any updates to the Project Schedule, and actions from the previous meeting.

6. Contractor shall schedule and hold Safety and Security Meetings, at minimum, on a monthly basis.

   a. Participants shall include SFMTA and Contractor's Site Manager and safety staff, as well as any others as necessary and as requested by SFMTA.

   b. Additional Safety and Security Meetings shall be held as determined by the SFMTA Project Manager to address specific or ongoing Project safety and security activities and issues.

7. The Weekly Status Meeting shall be held on a day of the week as agreed by SFMTA. This meeting will allow Contractor's Project Manager and SFMTA Project Manager to coordinate any details necessary to support Contractor's activities and any upcoming meetings or Milestones.

   a. Contractor's Project Team shall participate in this meeting with the Project Managers.

b. Contractor shall prepare and submit the Four-Week Work Plan and Three-Month Work Plan one Day in advance of the Weekly Status Meeting, so these plans may be discussed at the meeting.

8. Contractor shall initiate and support Working Group workshops as needed to support design progression. Working Groups include, but are not limited to, engineering workgroups for the purpose of design interface and integration, over-the-shoulder reviews to receive SFMTA input in advance to facilitate design progression and/or construction workgroups for the purpose of coordinating access for installations and/or testing execution.

9. Contractor shall schedule and hold Risk and Opportunities Assessment Meetings every six months (or more frequently as agreed by Contractor and SFMTA) to brainstorm and identify Contract risks and corresponding mitigations as well as identify possible opportunities for cost and time savings. SFMTA and Contractor will confer and agree on which staff will attend these meetings.

10. Contractor shall schedule and facilitate an annual Project Management Review Meeting for Project leadership to review the implementation methods of the Project Management Plan and address any opportunities for improvement. SFMTA Executives and Project Leadership team and Contractor Executive and Project Leadership team shall attend these meetings.

11. Contractor shall schedule and facilitate an annual Partnering Meeting for the Project team to learn about each other's roles, build team cohesion, and to foster a One-Team Approach environment of cooperation and trust. SFMTA and Contractor Project leadership will address the team and communicate lessons learned, feedback, safety messages, and other Project-wide announcements. All locally-based Project staff (SFMTA, Contractor, Installers and other third parties identified in the PMP) shall attend the Partnering Meetings.

12. Contractor shall establish a Failure Review Board and schedule and hold regular meetings starting when System testing begins, in accordance with Section 30.2.2.1 (Failure Review Board).

13. Contractor shall propose physical meeting locations for SFMTA approval. Contractor may hold virtual meetings upon approval by SFMTA.

3.5 CONTRACT DATA REQUIREMENTS LIST (CDRL)

1. Contractor shall develop and provide, at a minimum, the Deliverables identified within the list in Section 35. This list is not exhaustive of all Deliverables required on the Project and is provided as summary for the convenience of Contractor and SFMTA to establish the basis of Contractor's overall Deliverables list.

2. Contractor shall integrate the list contained in Section 35 with all Deliverables that Contractor deems necessary to implement the Project and demonstrate compliance with the Contract requirements. Contractor shall include these additional Deliverables in the final Contract Data Requirements List.

3. Contractor shall submit a preliminary Contract Data Requirements List [CDRL] to SFMTA fifteen (15) Days after NTP

4. Contractor shall update the Contract Data Requirements List at the time of the submission of the Project Schedule.

5. Contractor shall submit for SFMTA approval a document (as part of the PMP) mapping each item on the Contract Data Requirements List to the Payment Milestones set out in Appendix C of the Agreement and in accordance with Section 3.5.1.4, paragraph 7.

6. Contractor shall develop a document tree, based on Contractor's Contract Data Requirements List, that shows how the Deliverables support the requirements of the CBTC System Architecture.

7. Contractor shall maintain a CDRL status tracking list that identifies all Deliverable submissions.

8. Contractor shall submit the format and details of the Contract Data Requirements List to SFMTA for approval.

9. The final Contract Data Requirements List [CDRL] shall contain the following information, at a minimum, for each submittal item:

    a. Unique Submittal Identification Number

    b. Revision

    c. Document Title

    d. Submitted for Review and Acceptance or Submitted for Information

    e. Relevant Deployment Phase if applicable

    f. Baseline Planned Submittal Date

    g. Updated Planned Submittal Date

    h. Actual Submittal Date

    i. Status (Accepted, Accepted as Noted, Resubmit, Rejected)

3.5.1 PREPARATION AND REVIEW OF CDRL SUBMITTALS

1. Contractor shall apply the general requirements contained in this Section to all CDRL submittals. Additional and specific requirements for individual Deliverables are described within this Specification.

2. Contractor shall submit all Deliverables written in clear English. SFMTA will reject non-conforming submissions.

3. Contractor's Project Manager and Quality Manager shall sign all CDRL submittals certifying that Contractor has performed an internal review and confirming the submittal satisfies the requirements of this Contract and the approved quality procedures.

4. Contractor shall provide an Electronic Documentation Management System (EDMS) to store and maintain under Configuration management an electronic copy of each Deliverable.

    a. Contractor shall provide SFMTA unrestricted access to the EDMS.

    b. The Configuration management shall protect against unauthorized changes or deletions.

    c. The Configuration management shall allow SFMTA to view previous versions.

5. Contractor shall submit a CDRL Production and Template Plan [CDRL] for review and approval by SFMTA.

6. The CDRL Production and Template Plan shall incorporate all concepts or implementation processes described during the development of the Project Management Plan.

3.5.1.1 GENERAL FORMAT FOR SUBMITTALS

1. Contractor shall use a consistent format and document template for reports, Plans, Test Procedures, Drawings and other Deliverables.

2. Contractor shall submit these templates to SFMTA for approval prior to submitting the first Deliverable of an individual type.

3.5.1.2 IDENTIFICATION REQUIREMENTS

1. Each item submitted in accordance with the Contract CDRL List shall have a unique item number as described in Contractor's Configuration Management Plan.

3.5.1.3 CDRL FORMAT

1. Contractor shall submit all Deliverables electronically through Contractor's Electronic Document Management System, in PDF format with the same scale as used in print documents.

2. With the exception of Drawings or diagrams, the CDRL submittals shall be submitted on 8.5" x 11" paper size.

3. Contractor shall use track changes (underlining added text and line-through deleted text) to show Contractor's revisions in resubmittals of Deliverables.

4. Drawings shall conform to industry Standards as specified in Section 7.

5. Upon completion of System Final Design and Construction Final Design and successful related Final Design Review, Contractor shall provide SFMTA with electronic files of the Final System Design Documents and Drawings along with six (6) printed copies.

3.5.1.4 SFMTA REVIEW

1. With each CDRL submittal, Contractor shall provide a list of Contract requirements to which the submitted Deliverable satisfies.

2. SFMTA's approval of submittals does not relieve Contractor of its responsibility for the accuracy, conformity to requirements of the Contract Documents, compatibility of the described product with other integrated products and the rest of the CBTC System, or for completion of the Contract in accordance with all requirements of the Contract.

3. Contractor shall allot a twenty (20) day period for SFMTA review of submittals unless otherwise specified.

4. Contractor shall allocate additional time if Contractor submittals are greater than 100 pages or when third-party reviews are required.

5. Contractor shall coordinate submittal releases to facilitate SFMTA staff reviews. The duration of SFMTA review shall be represented in the schedule.

6. For each submittal, SFMTA will indicate the review status with one of the following:

   Approved: Contractor shall proceed with the Work described in the submittal.

   Approved As Noted: Contractor shall proceed as noted or commented by SFMTA. The document does not require a resubmittal. Any SFMTA comments or

margin notes are part of the content of the Deliverable and shall be preserved in the final version. Comments shall contain no actions to Contractor such as updating the document. Should the document require a future update or resubmittal, Contractor shall update the document to incorporate all SFMTA comments or margin notes into the main document text as part of that future update or resubmittal.

Resubmit: Contractor shall amend and update the document addressing SFMTA comments and resubmit it for another SFMTA review. SFMTA may review only the edited content or may review the entire document.

Reject: The document is rejected due to the Submittal's failure to meet material Contract requirements. Contractor shall rewrite the document to address the deficiencies and resubmit. SFMTA will review the entire document.

7. Resubmittals described in in paragraph 5 shall trigger a new SFMTA review period of equal duration to the original review period. The time required for the remedial Work and the additional review period shall not be considered an Unavoidable Delay.

8. As described in Appendix B, Section B2.1.1.1.1 (Payment Made Upon Completion) of the Agreement, the SFMTA will only make payment for a Major Milestone after the SFMTA has approved all Work for that Milestone. If a Milestone includes CDRL submittals, the SFMTA will only make the payment for that Milestone if all the submittals are "Approved" or "Approved As Noted". Contractor shall not invoice for a Milestone which includes submittals which are still pending the completion of SFMTA review or which have a "Resubmit" or "Reject" status.

3.5.1.5 DOCUMENTATION OF CDRL REVIEWS AND CONTRACTOR RESPONSES

1. SFMTA is available to work collaboratively with Contractor by participating in over-the-shoulder reviews of Contractor's work during Working Group sessions prior to the formal submittal of documents to expedite the document review process. Contractor shall describe these Working Groups and sessions in the Project Management Plan if deemed applicable.

2. Contractor shall update, revise and resubmit CDRLs if required after SFMTA review and when Contractor becomes aware of a material change to the document content.

3. Contractor shall respond to SFMTA comments to provide SFMTA with a greater understanding of the CDRL content or to support clarification of the CDRL compliance to the specification.

4. Contractor shall include a comment register table in the following submission of each CDRL that shows all comments that have been received, Contractor response and SFMTA agreement or the response.

5. Contractor shall propose a method to manage all review comments from multiple SFMTA reviewers to ensure that Contractor responds to all comments.

3.5.2 PROFESSIONAL SEAL

1. Contractor's Engineer of Record and all engineers who provide final approval to CBTC design documents and Drawings shall be registered in California as professional engineers in their applicable area(s) of practice.

2. Contractor shall stamp all design documents and Drawings and other submittals as required by applicable law.

3.5.3 RECORD DOCUMENTS AND DRAWINGS

1. Contractor shall document in detailed Drawings, documents, schedules, notes and other descriptive material the Configuration of all CBTC System installation, infrastructure, Hardware, and Software.

2. Contractor shall submit a complete final set of As-Built Record Documentation and Drawings [CDRL] at the end of each Phase.

3. Contractor shall clearly identify SFMTA-furnished infrastructure on all As-Built Record Documentation and Drawings.

4. Contractor shall not include any redline marking or markups in the As-Built Record Documentation and Drawings.

3.5.3.1 OFFICE RECORD DOCUMENTS AND DRAWINGS

1. Contractor shall maintain a complete current set of Project documents in electronic or hard copy for as appropriate, including:

    a. Conformed Contract Documents

    b. One Set of As-Built Drawings (including any revisions and special features, Shop Drawings, product data, and manufacturers' printed catalog cuts and data)

    c. Up-to-Date Set of Redlined Specifications and Revised Drawings

    d. Change Orders

    e. Accepted Submittals (CDRL documents)

    f. Clarifications or Explanatory Details and Specifications or Requests for Information

    g. Test Plans and Procedures

    h. Inspection Reports

    i. Test Records

    j. Field Test Reports and Records

    k. Factory Test Reports and Records

    l. Safety and Security Certification Plan and Report Related Documents

3.6 REPORTING AND METRICS

1. Contractor shall submit a Monthly Progress Report [CDRL] that uses narrative descriptions, Key Performance Indicators (KPIs) and data visualizations, as set out in this Section, to accurately describe the Contract progress to date, Contract issues, risks, and upcoming Work.

2. Contractor shall submit the Monthly Progress Report with the Monthly Progress Schedule prior to Contractor's submitting a Request for Payment. SFMTA will not process payment without an accompanying Monthly Progress Report or Monthly Progress Schedule.

3.6.1 MONTHLY PROGRESS REPORT

1. Contractor shall address the following topics in each Monthly Progress Report:
    a. Executive Summary of key accomplishments
    b. Planned key activities for the next month
    c. Concerns and Issues and mitigating action
    d. Monthly Progress Schedule (See Section 3.6.2)
    e. Project Progress:
        i. Design (Hardware and Software)
        ii. Software Development
        iii. Manufacturing Progress
        iv. Integration/Factory Testing
        v. Installation and Site Testing Works
        vi. Description of defects found and version
        vii. List of open defects and planned resolution (Software/Hardware) version
    f. Quality Status
        i. Inspections
        ii. Audits
        iii. Quality and Configuration Management Issues
        iv. Non-Conformance Status including Root Cause Analysis
    g. CDRL List
    h. Correspondence List
    i. Material Items List (electronic spreadsheet), further details are described in this Section.
    j. Material Repairs List, (include part number, serial number, and planned repaired by date)
    k. Invoice/Payment Status, referencing Project Milestones
    l. Change Orders in Progress
    m. Risk Register

n. Disadvantaged / Small Business Enterprise (DBE/SBE)

o. Open Request for Information (RFIs)

p. Open Waivers and Deviations

q. Listing and status of any maintenance service agreements, warranty agreements for any procured Hardware or any Software service agreements

2. Contractor shall submit to SFMTA a Monthly Progress Report Form [CDRL], including all proposed metrics and KPIs with their respective definitions and methodologies for review and approval thirty (30) Days after NTP. All subsequent progress reports shall be submitted in the format approved by SFMTA.

3.6.2 SCHEDULE REPORTING

1. Contractor shall use the Project Schedule to inform the SFMTA of critical events, reviews, and other events.

2. The Project Schedule shall have filtered reports for each Project team to use for their weekly planning.

3. Contractor shall submit a Monthly Progress Schedule [CDRL] to represent the total scope of the Project actualized to the agreed monthly date.

   a. The approval of any Monthly Progress Schedule shall not change the Project Schedule.

4. The Monthly Progress Schedule shall be submitted with an accompanying narrative.

   a. The narrative shall describe the progress made and justify the actual Work completed.

   b. Contractor shall include a forecast describing expected completion of in-progress activities in the narrative.

   c. This Project Schedule shall be updated to reflect the forecast.

   d. Contractor shall suggest strategies and control methods to control negative variances in its narrative.

5. Contractor shall submit a Four Week Schedule [CDRL] on a weekly basis starting after the Project Schedule has been approved.

6. The Four Week Schedule shall contain all Work completed from the previous week plus the next three weeks of the Project Schedule.

7. Contractor shall submit a Recovery Schedule [CDRL] if any Monthly Progress Schedule update shows negative float for any Project Milestones, key event, or technical deficiency resulting from any Phase Design Review.

8. The Recovery Schedule shall show modifications to the Project Schedule and the point where the Project Schedule “catches up” with the Contract Schedule.

9. Contractor shall submit a Time Impact Evaluation Schedule [CDRL] for any Change Orders and Contract Modifications showing impacts to the approved Contract Schedule.

a. Upon approval of a Change Order, Contractor shall incorporate the changed Work on the change order into the Contract Schedule.

b. Contractor shall update its Earned Value calculation to incorporate approved Change Orders.

3.6.3 MATERIAL ITEMS LIST

1. Contractor shall maintain a Material Items List (MIL)[CDRL] to track the delivery status of Equipment and Materials.

2. The MIL shall track all items contained within the List of Parts stated in Section 13.3.1 (Spare Parts Quantities).

3. The MIL shall be grouped by subsystem following a hierarchical organization.

4. The MIL shall include the following information, at a minimum, for each Deliverable item:

    a. Subsystem

    b. Part Description

    c. Size

    d. Original Equipment Manufacturer (OEM) and OEM Model Number

    e. Part Number

    f. Software Name and Version including Commercial Off-The-Shelf (COTS)

    g. Planned Procurement Date

    h. Estimated Lead Time

    i. Delivery Location including address

    j. Planned Delivery Date (Updated)

    k. Total Quantity To Be Delivered

        i. Actual Delivery Date

        ii. Actual Quantity Delivered

    l. Remaining Quantity To Be Delivered

        i. Planned Delivery Date

        ii. Actual Delivery Date

        iii. Actual Delivered Quantity

    m. Corresponding Migration Area

5. The Material Items List shall identify all EULAs and COTS software licenses to be provided to SFMTA.

6. Contractor shall submit the format of the MIL to SFMTA for review and approval thirty (30) Days after NTP.

7. Contractor shall update and include the MIL each month in the Monthly Progress Report.

8. Contractor shall develop a Material Delivery Process [CDRL] based upon the guideline provided in Appendix J to the Agreement.

9. Contractor shall design and submit a process that integrates the delivery of Equipment and Materials within the Material Items List to SFMTA operations and logistics efforts and SFMTA Enterprise Asset Management System (EAMS). EAMS is described in Section 13.5 (Equipment Asset Management).

3.7 COMMUNICATIONS AND CORRESPONDENCE

1. Contractor's Project Manager shall submit all Project Deliverables, Project correspondence, notifications or other contractually required documentation to SFMTA Project Manager.

3.7.1 CORRESPONDENCE

1. Contractor shall propose a process to track all correspondence between various stakeholders on the Project within fourteen (14) Days of NTP. Correspondence includes letters, emails, submittals, meeting minutes or other relevant documentation necessary to maintain a record of the Project and its status.

2. Contractor shall maintain an electronic record of all correspondence in its Electronic Document Control System.

3. Contractor shall propose a numbering scheme to SFMTA for approval within fourteen (14) Days following NTP.

4. All correspondence shall use the approved numbering scheme and be tracked by Contractor in a correspondence tracking list.

5. Contractor shall include the Correspondence List in the Monthly Progress Report.

3.7.2 REQUEST FOR INFORMATION

1. Contractor shall issue a formal Request for Information to SFMTA when seeking clarification or details on data, design, documentation, and System information, as described in Appendix E to the Agreement.

2. The Request for Information form shall contain the following fields:

    a. Date of Request for Information

    b. Date by which a Response is required

    c. Name of person requesting the Request for Information

    d. Subsystem or category of inquiry / migration area

    e. Requirement(s) to be reviewed

    f. Request for Information question or description

    g. Space for Request for Information response

3. Contractor shall propose a Request for Information form to SFMTA for approval within fourteen (14) Days following NTP.

3.7.2.1 TRANSMITTAL LETTERS

1. Contractor shall submit all Contractor submittals with a Letter of Transmittal form.
2. The form shall include the following information:
    a. Contractor's Name, address, and telephone number
    b. Submittal number, revision, and date
    c. Contract Title and Number
    d. Subject Identification including document/submission number or Drawing number
    e. Document is issued for Review/Acceptance or Information Only
    f. Signature of authorized issuer
    g. Contractor certification
3. Contractor shall submit a draft transmittal form for SFMTA approval within fourteen (14) Days following NTP.

3.8 ELECTRONIC DOCUMENT MANAGEMENT SYSTEM

1. Contractor shall use an Electronic Document Management System (EDMS) for Contractor to electronically issue CDRL submissions to SFMTA.
2. The EDMS shall:
    a. Provide notification of submissions
    b. Permit SFMTA access at any time
    c. Ensure that no documents can be deleted
    d. Allow SFMTA to manage, administer, and organize all CDRL submissions for the purposes of review, approval, and storage of Project documentation
    e. Provide version and Configuration control
    f. Record changes made to the CDRL
3. Contractor shall submit and provide instructions and training on how to use the EDMS.
4. SFMTA will provide the list of users who require access to the EDMS.
5. Contractor shall describe the process to coordinate the use of EDMS between Contractor and SFMTA in the Project Management Plan. This description shall include the brand and product name of the EDMS.

3.9 IDENTIFICATION AND SECURITY

1. Contractor shall confirm with SFMTA and comply with all SFMTA identification, check-in, badging and administration requirements when working in SFMTA facilities, including public and non-public areas.

2. SFMTA will issue Contractor ID badges. These badges shall be worn by Contractor personnel when working in SFMTA facilities.

3. Contractor shall maintain a log of all staff that shall have access to SFMTA facilities.

4. Contractor shall ensure any SFMTA badge and any other administrative, safety or other training is completed prior to site access.

3.10 SUPPORT FOR COMMUNITY RELATIONS PROGRAM

1. SFMTA will have primary responsibility for performing community relations work. SFMTA Communications Division will act as the primary liaison on behalf of the Project including its consultants, Contractor, and their Subcontractors.

2. SFMTA Communications Division will provide representation to the general public and the residents of potentially impacted neighborhoods, businesses and community groups. Contractor shall submit technical information, schedule updates, and other assistance to support SFMTA communications with all public entities.

3. Contractor shall maintain information and a schedule of Contractor events or activities that could impact any stakeholder group external to Contractor or SFMTA.

3.11 PROJECT MANAGEMENT CDRLS

Table 3-6: Project Management CDRL List

CDRL #	CDRL Title
03.01	Contractor Office and Warehouse Details
03.02	Organization and Staffing Plan
03.03	Project Management Plan (PMP)
03.04	Interim Project Schedule
03.05	Project Schedule
03.06	Contract Data Requirements List (CDRL)
03.07	CDRL Production and Template Plan
03.08	As-Built Record Documentation and Drawings
03.09	Monthly Progress Report
03.10	Monthly Progress Report Format
03.11	Monthly Progress Schedule
03.12	Four Weeks Schedule
03.13	Recovery Schedule
03.14	Time Impact Evaluation Schedule
03.15	Material Items List (MIL)
03.16	Material Delivery Process
03.17	CBTC Concept of Operations and Maintenance

4 ENGINEERING MANAGEMENT AND SUBMITTALS

4.1 PURPOSE

1. This Section provides requirements for engineering management of technical Deliverables of the Project. This Section describes the general requirements for the design and development of the CBTC System including Design Reviews, submittal requirements and requirements traceability.

4.2 DESIGN LIFE CYCLE

1. The Design Life Cycle is a concept of design which provides for the continuous update of the System Design throughout the Procurement Term to account for differences that may arise in the field as well as in response to changing conditions, while progressively locking more of the design as the Project stages advance. In the below requirements, the scope of design adjustments narrows with each stage. Contractor shall describe the Design Life Cycle process in the Systems Engineering Management Plan (SEMP) [CDRL] as described in this Section 4 and more specifically required in Section 4.3.1 (Systems Engineering Management Plan).

2. As the System designer, the Contractor bears responsibility for assumptions it makes during the design process. Contractor shall revise its designs at no additional cost to the SFMTA in the event actual conditions differ from Contractor's assumptions, regardless of any SFMTA approvals so long as SFMTA has not changed any applicable requirement stated in these Contract Specifications. SFMTA will make its best effort to assist Contractor in obtaining information necessary to reduce its design risk.

3. Contractor may, in the course of developing the System design, make assumptions about SFMTA operations, processes, procedures, and preferences. Contractor shall clearly disclose any assumptions it makes to the SFMTA. SFMTA will confirm any such assumptions through its approval of design submittals.

4. Contractor and SFMTA will be working closely together during design, involving informal communications and over-the-shoulder reviews. As SFMTA expresses its preferences during the design process, these statements shall not constitute changes to the Work but instead shall be considered Clarifications of the more general requirements contained in these Contract Specifications, as long as they do not conflict with any of those requirements.

5. If a preference expressed by SFMTA conflicts with the Contractor's assumptions and causes Contractor to revise its designs, Contractor shall make these revisions at no additional cost to the SFMTA as long as the conflicting assumptions were not stated in any previously approved submittal.

6. Once a submittal has been approved by the SFMTA as described in Section 3.5.1.4 (SFMTA Review), any changes to the submittal shall be considered changes to the Work and handled according to the procedures in Appendix E to the Agreement, except the changes described in Section 8.3.2.5 (Pilot Operating Period) which shall be handled as described in that Section.

7. Contractor shall implement a Design Life Cycle process to support a systematic incremental development of design, procurement requirements and appropriate verification and validation activities to develop System functionality in the following Design Life Cycle stages:

    a. Conceptual Design

    b. Preliminary Design

c. System Final Design

d. Construction Final Design*

e. Development and Manufacturing*

f. Delivery and Installation*

g. Field Testing*

h. RAM Demonstration*

i. System Acceptance*

* Indicates stage repeats for each Deployment Phase.

8. Contractor shall use the Design Life Cycle stages as Project quality review gates to monitor the design progress through joint Design Reviews, Factory Acceptance Tests, and other Project events with SFMTA and as specified in this Section 4 and in the relevant provisions of the Contract.

9. Contractor shall include all Design Life Cycle Milestones and gates, including Design Reviews, in the Project Schedule.

10. Contractor shall submit all required documentation to SFMTA prior to each scheduled Design Review or other Project review.

4.2.1 CONCEPTUAL DESIGN OBJECTIVES

1. During the Conceptual Design stage, Contractor shall develop and submit plans and documentation that describes the managerial and technical processes Contractor and SFMTA will use to manage and oversee the Project.

2. Contractor shall initiate the System Design Documents and develop them to a 30% level of development.

3. The System Design Documents shall, at a minimum:

   a. Describe System design goals and considerations

   b. Provide a high-level overview of the System architecture

   c. Describe the data design associated with the System

   d. Describe the human-machine interface and operational scenarios

4. Contractor shall breakdown and trace the Contract requirements into the System Requirements Document [CDRL] as described in Section 4.3.3 (System and Subsystem Requirements Documents).

5. The System Requirements Document shall conceptually describe how each subsystem/component functions within the CBTC System and includes any derived interface requirements that may be required.

6. Contractor shall document the traceability between these Contract Specifications and the System Requirements Document as part of the System Design Documents.

7. Contractor shall identify which of its CBTC products will be used in the design and submit to SFMTA Contractor's Base Product development plan and life cycle for that product line (the "CBTC Product Roadmap").

8. The CBTC Product Roadmap shall include:

    a. Contractor's product development plan for its Base Product for the 10 years following NTP.

    b. The generation of Base Product Hardware and Software specified in the System design and the stage in Contractor's Base Product life cycle that the SFMTA CBTC System design is based.

    c. A forecast on when the next generation of Base Product Hardware will be available for upgrade and the conceptual migration of any anticipated obsolescence as specified in Section 14 (Obsolescence Management).

    d. A forecast on when the SFMTA can be expected to no longer receive Software Updates without upgrading the System Hardware from the generation delivered during the Procurement Term.

9. Contractor's failure to include any Contract requirement in Project or Engineering management and planning documents or SFMTA's approval of such deficient documents shall not waive those excluded requirements or otherwise excuse Contractor from timely complying with those excluded Contract requirements.

10. The Conceptual Design Review (CDR) is the end of the Conceptual Design stage. For CDR, the Contractor shall submit the System Design Documents and Deliverables described in this Section.

    a. The Contractor shall allot the time identified in the Project Management Plan Section 10.1.3 for SFMTA Conceptual Design Review. SFMTA will provide a review status as defined in Section 3.5.1.4 (SFMTA Review) at or before the end of the allotted review time.

    b. If SFMTA exceeds the allotted review time, the number of Days in excess of the allotted review time shall be an Unavoidable Delay.

    c. When SFMTA Approves the CDR submittal, the Contractor shall proceed with the next stage of design.

    d. If the SFMTA returns the CDR with a "Resubmit" status, SFMTA will allow certain design efforts to progress to the next stage if they are unaffected by the update.

    e. If the CDR status is "Reject", SFMTA will require all design Work to pause until the CDR documents are resubmitted and Approved. This pause shall not be considered an Unavoidable Delay.

11. Contractor shall make changes to the design and implement corrective actions to address SFMTA comments made during the CDR.

12. Contractor shall include sufficient time in the Project Schedule for any remedial Work necessary to address SFMTA comments.

13. If remedial Work on the CDR submittal delays progress beyond the time allotted in the Contract Schedule, Contractor shall develop and implement a Recovery Schedule that details Contractor's corrective actions required to address SFMTA comments and the time needed to carry out those actions.

14. For the CDR, Contractor shall submit the System Design Documents and all Deliverables necessary to demonstrate that:

    a. All System Design Documents, Plans and Processes have been developed to 30% level of development and submitted to SFMTA for approval.

    b. The System Design Documents are compliant with the Contract Requirements.

    c. The Contractor's CBTC Product Roadmap includes at least 10 years' forecast on the next generation(s) of Contractor's Base Project, and shows SFMTA's CBTC System.

    d. All design Deliverables that support long lead items procurement, documentation to support Installer procurements, and descriptions and requests for SFMTA Furnished Items, including SFMTA's fiber-optic network, are included in the CDR submittal.

    e. The Contractor Reliability, Availability, Maintainability (RAM) team and Safety Assurance team has reviewed all documents in the Conceptual Design Review submittal.

    f. Contractor's Interface Management Plan is included in the CDR submittal. See Section 4.3.6 (Interface Management Plan).

    g. A Deployment and Migration Plan is included in the CDR submittal. See Section 8.3 (Project Phases).

    h. A Performance Simulation Plan [CDRL] is included in the CDR submittal. The Performance Simulation Plan shall describe how the Contractor will meet the performance simulation requirements in Section 16.4, including a list of assumptions and a list of scenarios to be tested.

4.2.2 PRELIMINARY DESIGN OBJECTIVES

1. During the Preliminary Design stage, the System Design Documents are further decomposed into low-level detailed design specifications for each system component, including hardware, internal communications, software, system integrity controls, and external interfaces. Contractor shall develop System Design Documents to a 60% level of development and Construction Documents to a 30% level of development.

2. The System Design Documents included in the Preliminary Design Review submittal shall describe how the CBTC System will functionally meet the requirements of the Contract Specifications.

3. Contractor shall trace Contract requirements to System Design documents in a draft Requirements Traceability Matrix (See Section 4.3.2) to be included in the Preliminary Design Review submittal.

4. Contractor shall fully describe the System architecture, data design, and all CBTC System interfaces, including human-machine interfaces and internal subsystem interfaces, in the System Design Documents submitted for Preliminary Design Review.

5. Contractor shall describe how the System will accommodate future expansions of CBTC Territory after Final Acceptance (for example, if the SFMTA lays down new track or commissions a new subway) in the System Design Documents submitted for Preliminary Design Review. SFMTA will obtain Contractor's support for such expansions in a Contract Modification.

6. Contractor shall clearly identify the elements of Contractor's Base Product Contractor must modify, develop, enhance or otherwise change to deliver a CBTC System meeting the Contract Specifications and describe the level of effort required for these changes in the Preliminary Design Review

submittal. SFMTA will compare this assessment to the Customization assessment provided by Contractor in its Proposal.

7. SFMTA will issue a Request for Qualifications (RFQ) to establish a pool of qualified Installers for installation work on this Project. Contractor shall provide SFMTA any special qualifications, specifications or criteria relevant to SFMTA's selection of an Installer as part of the Preliminary Design Review submittal.

8. Contractor shall update the CBTC Product Roadmap from Conceptual Design to reflect how Contractor's current design maintains alignment with Contractor's CBTC Product Roadmap. Contractor shall include the updated CBTC Product Roadmap in its Preliminary Design Review submittal.

9. The Preliminary Design Review (PDR) is the end of the Preliminary Design stage. For PDR, the Contractor shall submit the System Design Documents and Deliverables described in this Section.

    a. The Contractor shall allot the time identified in the Project Management Plan Section 10.1.3 for SFMTA Preliminary Design Review. SFMTA will provide a review status as defined in Section 3.5.1.4 (SFMTA Review) at or before the end of the allotted review time.

    b. If SFMTA exceeds the allotted review time, the number of Days in excess of the allotted review time shall be an Unavoidable Delay.

    c. When SFMTA Approves the PDR submittal, the Contractor shall proceed with the next stage of design.

    d. If the SFMTA returns the PDR with a "Resubmit" status, SFMTA will allow certain design efforts to progress to the next stage if they are unaffected by the update.

    e. If the PDR status is "Reject", SFMTA will require all design Work to pause until the PDR documents are resubmitted and Approved. This pause shall not be considered an Unavoidable Delay.

10. Contractor shall make changes to the design and implement corrective actions to address SFMTA comments made during the PDR.

11. Contractor shall include sufficient time in the Project Schedule for any remedial Work necessary to address SFMTA comments.

12. If remedial Work on the PDR submittal delays progress beyond the time allotted in the Contract Schedule, Contractor shall develop and implement a Recovery Schedule that details Contractor's corrective actions required to address SFMTA comments and the time needed to carry out those actions.

13. For the Preliminary Design Review (PDR), Contractor shall submit the System Design Documents and all Deliverables necessary to demonstrate that:

    a. All System Design Documents, Plans and Processes have been developed to 60% level of development and submitted to SFMTA for approval.

    b. System level requirements are defined and traced to the System Design Documents in a draft Requirements Traceability Matrix.

c. The Contractor's CBTC Product Roadmap includes at least 10 years' forecast on the next generation(s) of Contractor's Base Product, and shows SFMTA's CBTC System.

d. Hardware and Software architectures including all CBTC Subsystems are defined and meet the Contract functional and Performance Requirements.

e. Bills of Materials, Product documentation, Supplier certifications and expected delivery schedules meet the System and Project Schedule requirements.

f. Design of all interfaces complies with all requirements specified in the Interface Management Plan.

g. Automatic Train Supervision (ATS) and On-Board HMI layouts are included in the PDR submittal.

h. Layouts, floor plans and physical design requirements for Control Centers, Server Rooms, Wayside Signal Equipment Room are included in the PDR submittal.

i. The layout of Control Center Workstations set up is included in the PDR submittal.

j. The locations where the CBTC System needs to connect to the City-provided fiber-optic cable and network infrastructure are identified so that the City may begin its fiber-optic and network design.

k. The Contractor's Reliability, Availability, Maintainability team and Safety Assurance team has reviewed the System Design Documents in the PDR submittal.

l. The design is verifiable and the risks have been identified, characterized, and mitigated to an acceptable level.

m. Migration Strategy has been updated to reflect the latest design approach.

n. Test Plans are included in the PDR submittal.

o. Training program documentation is included in the PDR submittal.

p. Requirements for Operating rules is included in the PDR submittal.

q. Content required for Operations and Maintenance Manuals is included in the PDR submittal.

r. Human Factors documentation is included in the PDR submittal.

s. Construction Specifications and Drawings are advanced to a preliminary level of development (30%) for all Phases.

t. Preliminary plans for meeting the requirements for Heritage and Maintenance Vehicles specified in Sections 2.4.2 and 2.4.3 are included in the PDR submittal.

u. The CBTC System Performance Simulation Report defined in Section 16.4.2 is complete, and the simulated System meets the Performance Requirements specified in Section 16.

4.2.3 SYSTEM FINAL DESIGN OBJECTIVES

1. During the System Final Design stage, Contractor shall complete the System Final Design package that describes System and subsystem level Equipment and Software components. Contractor shall trace functional, non-functional requirements and derived requirements to the design implementation level.

2. Contractor shall update the CBTC Product Roadmap from Preliminary Design, or confirm the CBTC Product Roadmap submitted in PDR is final. Contractor shall include the final CBTC Product Roadmap in its Final Design Review submittal.

3. The System Final Design Review (FDR) is the end of the System Design Phase. The System Final Design Review will ensure that the System Final Design meets the requirements contained in these Contract Specifications. For FDR, the Contractor shall submit the System Design Documents and Deliverables described in this Section.

    a. The Contractor shall allot the time identified in the Project Management Plan Section 10.1.3 for SFMTA System Final Design Review.

    b. SFMTA will provide a review status as defined in Section 3.5.1.4 (SFMTA Review) at or before the end of the allotted review time. If SFMTA exceeds the allotted review time, the number of Days in excess of the allotted review time shall be an Unavoidable Delay.

    c. When SFMTA Approves the System Final Design, the Contractor shall proceed with the next Phase of the Project.

    d. If the SFMTA returns the System Final Design with a "Resubmit" status, SFMTA will allow certain Project efforts to progress to the next stage if they are unaffected by the update.

    e. If the System Final Design status is "Reject", SFMTA will require all Work to pause until the System Final Design is resubmitted and Approved. This pause shall not be considered an Unavoidable Delay.

4. SFMTA is responsible for modification of SFMTA Furnished Items identified in Section 9 (SFMTA Furnished Items), such as Vehicles, facilities, subways, tracks, streets and structures in the right of way. As part of the System Final Design submittal, Contractor shall provide SFMTA with sufficient descriptions and schematic diagrams of any modifications to SFMTA Furnished Items that will be necessary to accommodate Contractor's Equipment so that SFMTA and its design professionals may complete the design work, such as architectural, structural, mechanical, and electrical drawings.

5. Contractor shall make changes to the design and implement corrective actions to address SFMTA comments made during the FDR.

6. Contractor shall include sufficient time in the Project Schedule for any remedial Work necessary to address SFMTA comments.

7. If remedial Work on the FDR submittal delays progress beyond the time allotted in the Contract Schedule, Contractor shall develop and implement a Recovery Schedule that details Contractor’s corrective actions required to address SFMTA comments and the time needed to carry out those actions.

8. For the System Final Design Review, Contractor shall submit the final System Design Documents and Deliverables necessary to demonstrate that:

    a. All System Design Documents, Plans and Processes are complete, final and submitted to SFMTA for approval.

    b. System Final Design includes acceptable mitigation of Hazards identified in the safety and vulnerabilities analysis. All safety Hazards are traced to the mitigated design elements or applicable Safety Related Application Condition (SRAC).

c. System and Subsystem requirements are complete, agreed and traced to the design and verification documents

d. Contractor's current CBTC System design is reflected accurately in Contractor's CBTC Product Roadmap.

e. System Final Design is complete and supports proceeding with Software development, Control Center Hardware manufacturing, procurement, installation, testing and training.

f. Hardware and Software architecture meets the functional and Performance Requirements of the Contract Specifications.

g. Schematic (30%) Drawings of network and fiber-optic cabling are included in the Final Design Review submittal.

h. Designs of all interfaces comply with the Interface Management Plan requirements and all Interface Control Documents are included in the Final Design Review submittal.

i. The Contractor's Reliability, Availability, Maintainability team and Safety Assurance team has reviewed the System Design Documents in the FDR submittal.

j. Design is verifiable and that the risks have been identified, characterized, and mitigated to an acceptable level.

k. Human Machine Interface designs are included in the Final Design Review submittal.

l. Requirements derived from Contractor's Human Factors Analysis have been verified as correctly implemented.

m. Contractor's Migration Strategy is fully described in the Final Design Review submittal and is reflected in the training program, testing program, cutover strategy and operations and maintenance planning documentation included in the Final Design Review submittal.

n. The complete training program is described in the Final Design Review submittal, including training documents, the description of all training courses, identification of all personnel to be trained, including SFMTA Staff, Contractor Staff, Subcontractor Staff, and Installer Staff.

o. The complete testing program is described in the Final Design Review submittal, including requirements traced to test procedures to allow for procedure development and the list of test procedures to be executed for each test activity.

4.2.4 CONSTRUCTION FINAL DESIGN OBJECTIVES

1. Each Deployment Phase shall include a Construction Final Design Period used for progressing the Construction Documents covering that Deployment Phase's geographic boundaries, as described in Section 2.3 (Geographic Scope and Deployment Phases) to 100%.

2. As part of the Construction Final Design Review, Contractor shall submit final Construction Documents used for the manufacturing, construction, installation, testing, cutover and any other documentation required for implementation of the System within the applicable Deployment Phase of the Project.

3. The final Construction Documents shall contain all Contract Specifications, Bill of Materials, and Drawings necessary for construction, installation, cut-over, field testing and Commissioning of Contractor's Equipment for the applicable Deployment Phase.

4. The specifications provided by the Contractor as part of the Construction Documents shall:

    a. Include general requirements such as project management and QA programs, and safety procedures. The SFMTA will work with Contractor to draft these requirements;

    b. Include technical descriptions that define the Materials, workmanship, quality standards, and performance requirements for each aspect of the installation work;

    c. Include information about System elements necessary for the Installer to understand the work to be performed;

    d. Be organized into technical disciplines (e.g. structural elements, mechanical systems, electrical systems, and architectural features);

    e. Be prescriptive and clearly state what is required for compliant and complete installation work;

    f. Provide explicit instructions on the Materials and methods used to carry out the installation. Specifications may be specific as required, indicating required Contractor furnished Equipment and Materials, Shop Materials, and SFMTA Furnished Items to be used;

    g. Be written at a level of detail which balances cost with the necessary precision to meet the Project requirements, including performance requirements;

    h. Limit the unnecessary use of highly specific Shop Materials and methods.

5. The Drawings provided by the Contractor as part of the Construction Documents shall include, if applicable:

    a. Site plans (e.g., buildings, equipment rooms, control centers, etc.);

    b. Construction phasing plans;

    c. Floor plans showing the siting of Contractor's Equipment;

    d. Elevations (e.g., wall, racks, cases, panels, etc.);

    e. Sections;

    f. Details (Control Room, Wayside, and Vehicle);

    g. Schedules (e.g., Equipment, Conduit, Cable, and Electrical Panels);

    h. Systems plans (Block, Cable, and Wiring diagrams);

    i. Demolition plans (wayside, equipment rooms, etc.);

    j. Utility plans, including utility coordination maps (as required for utilities location, and installation).

6. The Bill of Materials provided by the Contractor as part of the Construction Documents shall:

    a. Be a comprehensive list of all the Materials, Equipment, components, and assemblies needed to complete the installation for the applicable Deployment Phase;

b. Break down work and Materials into sub-groups;

c. Assign units of measure and include quantities needed for each item;

d. Include an explanation of any estimation logic used to estimate quantities stated in the Bill of Materials;

e. Clearly designate which items are Shop Materials and provide sufficient description of the Shop Materials to allow Installers to price these items.

7. The final Construction Documents shall contain Hardware and Software Configurations for its networked Equipment such as servers, workstations and network devices for SFMTA or Installers to use when setting up the network.

8. The final Construction Documents shall contain Decommissioning Plans, which are instructions for the removal of any temporary equipment such as Cutover Cubicles used during deployment of the CBTC System, and as-built drawings marked up to indicate any existing equipment or connections which have been disconnected as part of the CBTC System installation and which can be safely removed.

9. The final Construction Documents will be used by SFMTA to bid out the work to Installers. The Construction Documents shall include an overview of the Project's scope and the portion of that scope covered in the Construction Documents.

10. Contractor shall assist SFMTA in responding to Installer RFIs as necessary to put the installation work out to bid and to support the Installers' work.

11. Contractor shall propose a Construction Final Design Review process to review the Construction Documents including lists of tools, Special Tools, staff, permitting or other measures required to complete any specific installation activity.

    a. The review shall ensure all quality control, material management, Software control and Configuration management planning efforts are in place and staffed.

    b. Handover criteria to Installer shall be included in the Construction Final Design Review submittal.

12. Contractor shall hold the Construction Final Design Review in advance of SFMTA advertising the construction contract for the Deployment Phase for which the design is being produced. The Construction Final Design Review will ensure that the Construction Final Design meets the requirements contained in this Specification.

    a. The Contractor shall allot the time identified in the Project Management Plan Section 10.1.3 for SFMTA Construction Final Design Review.

    b. SFMTA will provide a review status as defined in Section 3.5.1.4 (SFMTA Review) at or before the end of the allotted review time. If SFMTA exceeds the allotted review time, the number of Days in excess of the allotted review time shall be an Unavoidable Delay.

    c. When SFMTA Approves the Construction Final Design for a Deployment Phase, the Contractor shall proceed with the next activities in the Deployment Phase.

    d. If the SFMTA returns the Construction Final Design with a "Resubmit" status, SFMTA will allow certain activities to progress to the next stage if they are unaffected by the update.

e. If the Construction Final Design status is "Reject", SFMTA will require all Work on the Deployment Phase to pause until the Construction Final Design is resubmitted and Approved. This pause shall not be considered an Unavoidable Delay.

13. Contractor shall make changes to the design and implement corrective actions to address SFMTA comments made during the Construction Final Design Review.

14. Contractor shall include sufficient time in the Project Schedule for any remedial Work necessary to address SFMTA comments.

15. If remedial Work on the Construction Final Design Review submittal delays progress beyond the time allotted in the Contract Schedule, Contractor shall develop and implement a Recovery Schedule that details Contractor's corrective actions required to address SFMTA comments and the time needed to carry out those actions.

4.2.5 DEVELOPMENT AND MANUFACTURING OBJECTIVES

1. Contractor may work towards these Development and Manufacturing Objectives at any time following SFMTA approval of the System Final Design. SFMTA will verify the completion of these objectives upon delivery or through its QA process.

2. In this stage, Contractor shall develop and configure the CBTC Software and procure and manufacture all required CBTC and Project Equipment.

3. During this stage, Contractor shall perform unit testing, subsystem tests and System integration testing of Software and Hardware components.

4. Contractor shall submit documented traceability of all functional and derived requirements to subsystem and System integration test case documentation.

5. Contractor shall ensure material is available as required to support the activities required by the Project Schedule.

6. Contractor shall schedule adequate time in the Project Schedule for procurement of material, inventory and delivery.

7. Long lead procurement item shall be reviewed with SFMTA as required by the Project Schedule.

8. Contractor shall conduct System Factory Acceptance Test (FAT) to verify and validate that the CBTC System Hardware and Software performs as required.

    a. For every Software release after the FAT is completed, Contractor shall perform a Software demonstration to show and describe the new modified functionality before the Software is loaded onto SFMTA's System.

4.2.6 DELIVERY AND INSTALLATION

1. During the delivery and installation stage, Contractor shall deliver the Hardware and Software, provide Quality Control oversight for installation of the Hardware, install Software, witness Post-Installation Check-Out (PICO) tests, and verify the PICO test reports provided by the Installer.

2. SFMTA will separately contract with one or more Installers for Equipment installation on the Vehicles, along the wayside, and in network rooms, Control Centers, data centers and offices. Contractor shall conduct joint readiness reviews with SFMTA staff and Installers.

3. At a minimum, these joint readiness reviews shall occur within 15 Days of the SFMTA giving each Installer notice to proceed, prior to the delivery of Materials, and prior to the start of the installation work of each Deployment Phase.

4. During the joint readiness reviews, Contractor shall:

    a. Review the Construction Documents with the Installer to ensure understanding and receive feedback.

    b. Review Contractor's plans and schedules for installation, Deployment, Migration and testing with the Installer.

    c. Solicit feedback from the Installer regarding the constructability of Contractor's designs.

    d. Communicate any assumptions Contractor has made about the Installer's work, such as task durations, work inspection and testing, and receive feedback from the Installer on these assumptions.

    e. Review the list of Shop Materials and confirm Installer will provide all Shop Materials.

    f. Review the Materials and Equipment lists to be provided by Contractor.

    g. Review any Special Tools needed for the installation and provide instructions on how to operate Special Tools.

5. Joint readiness reviews shall be included in the Project Schedule and as quality gate milestones.

6. Contractor shall revise its designs, plans and schedules as required in response to information from Installers, as approved by SFMTA, arising from the joint readiness reviews, to account for different site conditions, or to resolve issues arising during installation.

4.2.7 FIELD TESTING

1. During Field Testing, Contractor shall test the CBTC System to ensure that the System performs as specified and meets all safety assurance requirements required for Revenue Service. Field Testing includes Site Engineering Testing, and Site Acceptance Testing.

2. Contractor shall adjust its designs to address issues arising from field testing which require a change to the System design to solve.

3. Contractor shall provide all documentation required for SFMTA to put any part of the System into Revenue Service.

4. Revenue Service cannot commence until the California Public Utilities Commission (CPUC) issues Safety Certification for the CBTC System or the portion(s) of the CBTC System delivered to date.

4.2.8 RAM DEMONSTRATION

1. During the Reliability, Availability and Maintainability Demonstration (RAM Demonstration), a demonstration of compliance to Reliability, Availability, and Maintainability requirements will be performed.

2. Contractor shall adjust its design as needed to improve RAM performance if the System is not meeting RAM requirements.

3. The successful completion of the RAM Demonstration for the final Deployment Phase will lead to the Final Acceptance. See Section 8.3.3 (RAM Demonstration).

4.2.9 SYSTEM ACCEPTANCE

1. For System Acceptance Contractor shall submit evidence of the successful completion of all Project work within a Deployment Phase, or the entire Project, in compliance with the Contract requirements contained in this Specification.

2. Contractor may request Conditional Acceptance after completion of each Deployment Phase. The completion of the last Deployment Phase's System Acceptance shall lead to Final Acceptance.

3. Contractor shall ensure the delivered CBTC System, including its subsystems, Hardware, and Software, is equivalent to the latest service-proven generation of Contractor's Base Product line at the time of Final Acceptance.

4.3 ENGINEERING MANAGEMENT DELIVERABLES

1. Contractor shall submit engineering management planning and control Deliverables to ensure development and management of the design, incremental compliance and agreement to requirements, and technical risk management.

2. Contractor shall document traceability with each design submittal showing the compliance to Contract requirements.

3. Contractor shall ensure design submittals meet all Contractor's product requirements in addition to the requirements in these Specifications.

4.3.1 SYSTEM ENGINEERING MANAGEMENT PLAN

1. Contractor shall supply a System Engineering Management Plan (SEMP) [CDRL] in compliance with IEEE 15288 Standard as specified in Section 7 (Codes and Standards).

2. The SEMP shall include the overall management of requirements and detail requirements for supporting engineering plan documents.

3. The SEMP shall describe management processes and procedures to implement and control:

    a. Design Scope

    b. Level of Effort

    c. Design Team Organization

    d. Applicable Processes

    e. Design Life Cycle

    f. Applicable Standards

    g. Design Tools

    h. Interfaces

i. CDRL Deliverables

4. The SEMP shall describe Contractor's plan to make adjustments to the System design, including upgrading Hardware and other System components, over the course of the System Procurement Term to ensure that the delivered CBTC System is equivalent to the latest service-proven generation of Contractor's Base Product line at the time of Final Acceptance.

4.3.2 REQUIREMENTS MANAGEMENT

1. Contractor shall submit a Requirements Management Plan [CDRL] describing:

   a. Roles and responsibilities of Project stakeholders with respect to System and Contract requirements.

   b. The process by which Contractor will confer with SFMTA to resolve any ambiguity in Contract requirements.

   c. The process to incorporate changes to Contract requirements due to Project changes or clarifications made through Requests for Information. Contractor shall follow the CBTC Change Control Process as defined in Section 15.4 to update requirements and the associated impacted designs.

   d. Methodology to breakdown various requirements so that they apply to specific subsystems or components.

   e. Development of the Requirements Traceability Matrix (RTM) [CDRL]. Contractor shall include descriptions and purpose of all requirement attributes used within the RTM.

      i. The RTM shall have compliance traceability from analysis to implementation and verification and validation of all technical requirements.

      ii. The RTM shall have a report that indicates the documented evidence of compliance against all technical requirements.

   f. Metrics to track the incremental development and verification of requirements through the Project life cycle.

2. Contractor shall provision and use a COTS Object-Oriented requirements management tool to manage and report on requirements traceability.

   a. The tool shall have formatting and output functionality that supports SFMTA review for compliance of design documentation.

   b. Contractor shall develop, submit and provide access, licensing and training to SFMTA if required to use such functionality.

4.3.3 SYSTEM AND SUBSYSTEM REQUIREMENTS DOCUMENTS

1. Contractor shall produce System Requirements Documents (SRD) [CDRL] and deliver them to SFMTA as part of the CDR submittal.

2. The SRD shall consist of a set of technical System requirements derived from the Contract requirements contained in this Specification.

3. The SRD shall include interface requirements derived from the technical requirements.

4. The Subsystem Requirements Documents (SSRD) [CDRL] shall describe in detail the requirements for each subsystem and components, such that their functions support the interfaces and System functions described in the SRD and Contract requirements.

5. The SRD and SSRD shall detail all required functional and non-functional Software and Hardware requirements in clear English, categorized (such as functional, safety) and verifiable.

6. The Contractor shall use the SRD and the SSRD to develop the System design.

7. The SRD and SSRDs shall have traceability to the requirements contained in these Contract Specifications.

8. The SRD, SSRDs, and their traceability to the requirements contained in these Specifications shall be kept up to date throughout the Procurement Term so as to reflect all changes to the Contract Specifications executed through Change Orders and Contract Modifications.

4.3.4 SYSTEM FUNCTIONAL DESCRIPTION

1. Contractor shall include a System Functional Description (SFD) [CDRL] as part of the System Design Documents.

2. The SFD shall describe at a minimum the following:

    a. Describe the architecture of the CBTC System including location of Hardware and Software subsystems; specifically describing if subsystems are centralized or distributed as required to meet the SRD and the Contract requirements.

    b. List the subsystems that constitute the overall CBTC System.

    c. Provide a functional description and block diagram by subsystems showing how various subsystems interact to create each specific System function.

    d. Identify all Software by category (e.g. application dependent, application independent and Commercial Off The Shelf [COTS]).

    e. Identify all Hardware as Vital or non-Vital and if it is a Line Replaceable Unit (LRU).

4.3.5 SOFTWARE PROJECT MANAGEMENT PLAN

1. Contractor shall include a Software Project Management Plan (SPMP) [CDRL] as part of the System Design Documents.

2. The SPMP shall be consistent with ISO/IEC/IEEE 16326:2009

3. The SPMP shall include at a minimum:

    a. The processes to be used to develop, factory test, and field test the CBTC Software and its components.

    b. The processes to be used to develop and perform regression testing.

    c. The language that will be used to write Software source, object and other codes, including third-party software.

    d. The metrics that will be implemented to measure progress of the Software development. Proposed metrics include, at a minimum:

i. Number of new or modified functions

ii. Percentage and number of lines of code modified

iii. Percentage and numbers of lines of code added

iv. Percentage of Software adaptation required to meet the Contract Requirements

e. The methodology that will be used to define and monitor the level of Software product adaptation.

f. The timing and process Contractor shall use to control and deploy Software to test or production.

g. A description of Contractor's review process that identifies and makes recommendations for compliance to regulatory or technology changes that occur during the Procurement Term that may impact CBTC System design, functionality, or implementation. Contractor shall continue this review process until Final Acceptance.

h. A description of Contractor's review process that identifies and makes recommendations for Software Updates and Upgrades to ensure continued parity with the latest release of Contractor's Base Product. The process shall ensure SFMTA's CBTC System development matches Contractor's Base Product development through Final Acceptance. Contractor shall continue this review process until Final Acceptance.

i. A description of Contractor's process for identifying, classifying, tracking, and resolving Software Bugs, such that the Software is free of any known bugs at Final Acceptance.

4.3.6 SYSTEM INTEGRATION MANAGEMENT PLAN

1. Contractor shall submit a System Integration Management Plan (IMP) [CDRL] which describes how the internal and external subsystems (for example how the CAD/AVL System and onboard Vehicle systems) will be integrated to meet CBTC Contract Specifications.

2. The System Integration Management Plan shall describe the following:

   a. Interface and integration organization as part of an overall Systems Engineering organization.

   b. Integration coordination and management between SFMTA, Third-Party System vendors and Installers.

   c. A list of Third-Party Systems to be integrated with, including functional descriptions of the necessary integrations.

   d. CBTC System integration processes, roles and responsibilities, inputs and outputs, and activities for each life cycle Phase.

   e. Process to fully integrate the CBTC System with SFMTA technology systems, including Third-Party Systems, and process to ensure the correct interface of new CBTC Equipment to the existing equipment.

   f. Strategy for identifying, specifying, implementing, and integrating all Interfaces.

   g. Schedule of all System Integration activities including meetings, critical review points, and Milestones.

   h. A listing of the subset of documents Contractor will develop, review, or reference as part of the System integration process and Final Acceptance.

i. Methodology that shows incremental confirmation of successful integration as components are integrated into subsystems and subsystems are integrated together.

j. Description of interface Configuration control tools and methods

k. Third-Party System testing plan which includes a testing schedule, test scenarios, resources required (including from SFMTA and Third-Party System vendors) and procedures for verifying the integrations with Third-Party Systems meet the functionality set forth in these Specifications.

3. The System Integration Management Plan shall describe Contractor's responsibilities, staffing, tasks and activities to support SFMTA in building and managing interfaces to Third-Party Systems.

4. The System Integration Management Plan shall describe Contractor's responsibilities, staffing, tasks and activities as well as the responsibilities of SFMTA and third parties such as the Vehicle manufacturer in building and supporting the on-board integration between the CBTC System and Vehicle systems.

4.3.7 INTERFACE MANAGEMENT PLAN

1. Contractor shall create an Interface Management Plan [CDRL] documenting the process and tools that will be used to plan, define and manage and maintain internal and external interfaces.

2. Contractor shall include all information and development necessary to ensure successful integration of these interfaces in the Interface Management Plan.

3. The Interface Management Plan shall describe Contractor's responsibilities, staffing, process and procedures to support SFMTA in building and managing interfaces to Third-Party Systems.

4. The Interface Management Plan shall describe Contractor's responsibilities, staffing, process and procedures as well as the responsibilities of SFMTA and third parties such as the Vehicle manufacturer, in building and managing the on-board integration between the CBTC System and Vehicle systems.

5. The Interface Management Plan shall include:

   a. Stakeholders' identification and their roles and responsibilities

   b. Internal and external interfaces definition

   c. Internal interface management process and tools

   d. External interface management process and tools

   e. Interface Control Documents structure

   f. Listing of all required Interface Control Documents and their contents

   g. Interface verification and validation plan and schedule

4.3.8 VERIFICATION AND VALIDATION PLAN

1. Contractor shall submit a System Verification and Validation (V&V) Plan [CDRL].

2. The V&V Plan shall describe the processes and procedures that are used to confirm compliance to both Contract and System requirements.

3. The V&V Plan shall validate the intended objectives of the Project to achieve a reliable, maintainable, contractually compliant and safe CBTC System that supports SFMTA operations and SFMTA commitment to a positive customer experience.

4. The V&V Plan shall detail the process and procedures to verify that the System design and implementation is at the required quality level.

5. The Verification and Validation Plan shall describe the acceptable methods of evidence required to show compliance to the requirements. These methods shall include documented analysis, inspection, test, or demonstration. Based on the methodology agreed for applicable requirements, this evidence support Safety Certification processes.

6. The V&V Plan shall describe the following:

    a. Verification and Validation Roles and Responsibilities

    b. Applicable verification methods, where and how applied

    c. Applicable validation methods, where and how applied

    d. V&V Phases and workflow

4.3.9 VERIFICATION AND VALIDATION REPORT

1. The Verification and Validation Report (VVR) [CDRL] shall have verification and validation (V&V) reporting that consists of V&V Task Reports, V&V Activity Summary Reports, V&V Anomaly Reports, and the V&V Final Report.

2. Contractor shall submit the VVR [CDRL] to SFMTA.

3. The VVR shall include all V&V results and findings.

4. When changes are made due to field anomalies, the V&V Final Report shall be updated for these changes.

5. The VVR content shall support the Safety Certification requirements.

4.4 ENGINEERING MANAGEMENT AND SUBMITTALS CDRLS

Table 4-7: Engineering Management and Submittals CDRL Table

CDRL #	CDRL Title
04.01	System Engineering Management Plan (SEMP)
04.02	Requirements Traceability Matrix
04.03	Requirements Management Plan
04.04	System Requirements Documents (SRD)
04.05	Subsystem Requirements Documents (SSRD)
04.06	System Functional Description (SFD)
04.07	Software Project Management Plan (SPMP)
04.08	System Integration Management Plan (IMP)

CDRL #	CDRL Title
04.09	Interface Management Plan
04.10	System Verification & Validation (V&V) Plan
04.11	Verification & Validation (V&V) Report (VVR)
04.12	Performance Simulation Plan

5 QUALITY ASSURANCE AND QUALITY CONTROL

5.1 PURPOSE

1. This Section provides requirements for Contractor's Quality Assurance (QA) program that provides independent assurances that Project activities are consistently performed according to plans and Contract requirements, using best industry practices and auditable methodology.

5.2 GENERAL REQUIREMENTS

1. Contractor shall include specific Quality Assurance (QA) and Quality Control (QC) activities in the Project Schedule showing Contractor's active review of all Project Deliverables.

2. SFMTA will maintain its own Project QA team. Contractor shall cooperate and comply with all SFMTA-led QA activities, including oversight, audits and inspections.

3. Contractor shall use the Standards specified in Section 7 (Codes and Standards), Contractor proposed Standards, Project Deliverables, Contract documents, and SFMTA policies and guidelines as the basis to develop and perform the Quality Assurance Work.

4. Contractor shall enforce its QA/QC policies and processes on all parts of the Project under its control, including Subcontractors.

5. Contractor shall extend its QA/QC policies and process to Installers that perform Project work. SFMTA will enforce violations of Contractor's QA/QC policies by third parties contracted to SFMTA.

6. Contractor shall perform all QA functions required by the Contract. Contractor shall perform QC oversight, audit, inspection for Third-Party Installers.

7. Contractor's oversight shall verify the quality of installations against approved design documentation.

8. Contractor shall notify the SFMTA of any non-conformances to the Contract Specifications as soon as it becomes aware of them.

9. Contractor's oversight of its Subcontractors shall include sampling and review of products, records, procedures, processes, manufacturing operations, and QC and QA methods.

10. Contractor's QA staff shall be independent from production.

11. Contractor and Subcontractor QC and QA staff shall not participate in the production of the Project Work.

5.3 DOCUMENTED QUALITY MANAGEMENT SYSTEM

5.3.1 QUALITY ASSURANCE PROGRAM PLAN

1. Contractor shall develop and submit to SFMTA a comprehensive Quality Assurance Program Plan (QAPP) [CDRL].

2. The QAPP shall detail how the QA and QC will be conducted during the Procurement Term.

3. Contractor's QAPP shall ensure and document that all activities and Deliverables in Contractor's scope conform with all Contract Specifications and approved System designs.

4. The QAPP and QA/QC activities shall comply with the requirements of the FTA Quality Management System Guidelines, Codes and Standards specified in Section 7.

5. The QAPP shall ensure and document that the quality of all activities, including design, purchasing, inspection, handling, documentation, assembly, fabrication, testing, training, integration, storage, shipping, third party installation, certification, and warranty/repair work meet Contract requirements.

6. The QAPP shall describe the program quality procedures and the quality audit process of Contractor and any Subcontractors and Suppliers.

7. The QAPP shall describe the quality requirements for each type of activity and describe how Contractor will ensure that quality, including control techniques for the design, build/install, testing and all other Project elements, meet Contract requirements.

8. Contractor shall verify Subcontractor or Supplier compliance with the accepted QAPP.

9. Contractor shall include QAPP requirements in subcontracts and supply agreements and review Subcontractors' and Supplier quality control plans.

10. Contractor shall submit written confirmation that Subcontractors' and Suppliers' quality control plans comply with the accepted QAPP[CDRL].

11. Contractor shall verify Installer compliance with the accepted QAPP.

12. Contractor shall review Installer quality control plans for conformance with the accepted QAPP.

13. Contractor shall submit written confirmation to SFMTA that Installer quality control plans comply with the accepted QAPP or issue a report detailing discrepancies between the Installer quality control plans and the accepted QAPP.

14. Contractor shall perform QA on Installation Activities. Contractor shall submit all findings to SFMTA.

15. Contractor shall not start any Phase review, testing or inspection until the QAPP has been accepted by SFMTA.

16. Contractor's QAPP shall include:

    a. Contractor's Quality Assurance Manual, which describes the quality policy, quality organization, and quality procedures.

    b. Description and process for the development, distribution, and control of Quality checklists.

    c. Evidence that requirements are traced to Quality checklists.

    d. A description of how Quality checklists shall be controlled, distributed, and verified using Contractor's requirements management database tool.

    e. Quality checklists that include Design Criteria Conformance Checklists and Construction Conformance Checklists (see Section 6.2.3) and used to support Phase Design Reviews.

f. Quality checklists that are filterable and exportable in readable Microsoft Word, Excel, and Adobe PDF formats, which shall be included in the QAPP.

g. A master quality organization chart including roles and responsibilities of QA and QC staff and their interactions with all Project stakeholders including SFMTA QA staff.

h. Quality organization charts for Contractor and all Subcontractor staff specific to any manufacturing and assembly operations that produce designed CBTC Equipment. These organization charts shall indicate QA/QC staff assigned to assure critical quality functions including receiving inspection; source inspection, in-process and final inspection, non-conforming material, testing product, Contract compliance and corrective action procedures.

i. A description of the responsibility and authority of Contractor staff responsible for performing QC and QA activities and quality audits. At a minimum, the QAPP shall describe the specific responsibility and authority of each person assigned to perform the following:

    i. Identification and recording of non-conforming items or conditions, including when design documents do not conform with Contract requirements or Contractor design.

    ii. Development of recommendations for corrective action through appropriate channels.

    iii. Verification of appropriate corrective action or implementation of solutions to correct non-conforming items or conditions, including the evaluation of product conformance, product acceptability, and product Support.

    iv. Implementation of actions to prevent or control further non-conformances, including ensuring the conformance of the test environment.

j. A description of processes to control schedule and cost Projections to not compromise the quality of products or services delivered under the terms of the Contract.

k. A description of processes which ensure that Contractor QA staff shall have authority and the hierarchical management structure to ensure that a non-conforming product or service will not be delivered to SFMTA through:

    i. Identification and evaluation of quality problems

    ii. Development, recommendation, or provision of solutions to correct non-conformances

    iii. Verification of solution implementation

    iv. Control further processing, delivery, or installation of a non-conforming item until proper disposition has been obtained

l. A description of the qualifications of Contractor's staff performing inspections or tests (where applicable), such as education, prior experience, training, and certifications.

m. A description of Contractor's record-keeping systems for staff certification and qualifications, including how updates will be furnished to SFMTA when QA management staff and certification status changes occur.

n. A description of Contractor's submittal management and design process control, including all QC certifications, Drawing check processes and Configuration management.

o. A description of Contractor's process to assure quality of receiving, handling, storage, and control of Materials and Equipment, including product identification and traceability.

p. A description of Contractor's Subcontractor, Supplier selection and control requirements, process and audit plan.

q. A description of Contractor's control methods of build, assembly, and monitoring of installation processes, including special processes.

r. A description of Contractor's Inspection and Test Program required by the QA/QC program.

s. A description of Contractor's policies for control of measuring and test equipment.

t. A description of Contractor's preventive action plans and policies for control of non-conforming conditions.

u. A description of Contractor's process to manage defects and non-conformances identified during the Procurement Term. This process shall include management of Punch Lists and defect logs to ensure completion of these items in agreement with SFMTA.

v. A description of Contractor's Failure Reporting and Corrective Actions System as required in Section 30.2.2.

w. A description of Contractor's Stop Work procedures, including authorization to stop Project Work, approvals required, and any restrictions.

x. A description of Contractor's facility and handover criteria management processes.

y. References to the major Phase reviews, manufacturing, installation, and inspection Milestones in the Project Schedule.

z. A description of Contractor's Quality Assurance and Quality Control required procedures.

aa. A description of the methods and audit plan for Contractor Software and Hardware Quality Assurance Plans.

bb. A description of Contractor's staffing and documentation required to evaluate and control the Installer quality including Acceptance criteria required for Contractor acceptance of Installer's work.

cc. A description of Contractor's Configuration control processes for all documentation, Equipment, Hardware, Software and any other Project Deliverables.

dd. A description of Contractor's plan to verify the physical conformance of Equipment manufactured and installed under this Contract.

ee. A comprehensive collection of forms for documentation of Quality Assurance Program activities. Forms shall be designed to assure compliance of Materials, processes, staff, and products to the accepted design Drawings and applicable specifications.

ff. The accepted QAPP and supplemental manuals of procedures and instructions shall be subject to periodic audits by SFMTA.

5.3.2 QUALITY ASSURANCE MANUAL (QAM)

1. The applicable Contractor, Subcontractor and Supplier Quality Assurance Manuals [CDRL] shall be listed in the QAPP.

2. Contractor shall submit verification that all Subcontractor quality plans and processes are compliant to Contractor's QAM.

3. Contractor shall ensure that all engineering, procurement, manufacturing, inspection and test plans and procedures are developed using the methods and procedures found in the manual.

4. The QAMs shall contain as a minimum:

    a. The authority of the quality program

    b. The QC responsibilities of every department supporting quality

    c. The respective organizations' quality policies

    d. A designated company representative in each Contractor, Subcontractor, and Supplier organization, who has the responsibility and authority to ensure that quality programs are implemented and enforced.

    e. All quality functions and relationships.

    f. Written procedures defining methods to implement and maintain the organization's QC and QA Program, including Quality Management, Configuration Management, Design Quality, Installation, and Test procedures, and

    g. The written procedures listed below including those of Subcontractors and Suppliers to ensure effective implementation of QA activities.

5. Contractor shall develop and provide Quality Control Procedures and Process to control QC activities. Contractor shall submit the following written procedures, at a minimum:

    a. Design control, including technical documentation and engineering changes

    b. Transmission of all QA requirements to procurement sources

    c. Surveillance of Subcontractors

    d. Receiving, source, in-process, and final inspections

    e. Production and process control

    f. Transportation Controller, Train Operator and other staff certifications and qualifications

    g. Functional testing

    h. Discrepancy control

    i. Calibration and certification of measuring and test equipment

    j. Drawing control

    k. QA records

    l. Shipping and receiving, handling, and storing

    m. Selection of qualified procurement sources

n. Evaluation and assessment of Subcontractors' QA programs

o. Monitoring of Subcontractor QA performance

p. Evaluation of procured articles against purchase order requirements

q. Evaluation of conformance of CDRL Items to Contract requirements

6. Contractor shall evaluate the training needs of Contractor's staff who perform activities affecting quality.

7. Contractor shall provide the necessary training to its staff to ensure they fully understand their responsibilities with respect to Contractor written QA procedures.

5.3.3 SOFTWARE QUALITY ASSURANCE PLAN (SQAP)

1. Contractor shall submit a Software Quality Assurance Plan (SQAP) [CDRL].

2. The SQAP shall be compliant to IEEE Std 730-2014.

2. The SQAP shall cover the entire CBTC Software life cycle; including all Software and firmware provided to the Project.

3. All Software provided by Contractor for the CBTC System, whether this item is considered Commercial Off-The-Shelf, application-dependent, or application-independent, shall be tested for its intended use and application as specified in Section 7.2.3.

4. The SQAP shall have a schedule of audits of Software development processes by Contractor's internal Quality Assurance organization.

5. The SQAP shall have a process for tracking and resolving any defects identified during the audits of Software development processes.

6. The SQAP shall support the achievement of the RAM Program and specifically the requirements stated in Section 30.

7. The SQAP shall support the achievement of the System Safety and Certification Program and specifically the requirements stated in Section 6.

8. The SQAP shall describe how the results of internal development verification, validation reviews and audits are recorded and resolved.

9. The SQAP shall describe how non-conformances are identified

10. The SQAP shall describe the methods and tools that shall be used for tracking, resolving, and documenting non-conformance issues.

11. The SQAP shall describe a plan for how Contractor's and Subcontractor's Software Quality Assurance activities will be reported.

12. Contractor's and Subcontractors' Software Quality Assurance activities shall include Software product assurance, process assurance, and process compliance evaluations, and Software product reviews.

13. Contractor shall enforce requirements of the SQAP on all Subcontractor and Supplier developed Software.

14. Contractor shall provide SFMTA with access to review all Contractor, Subcontractor and Suppliers' SQAP enforcement activities.

5.3.4 HARDWARE QUALITY ASSURANCE PLAN (HQAP)

1. Contractor shall submit a Hardware Quality Assurance Plan (HQAP) [CDRL] that covers the life cycle of Hardware development.

2. The HQAP shall support integration of Hardware into SFMTA operational infrastructure and ensure and control Hardware quality conformances.

3. The HQAP shall include:

    a. Requirements for Certificates of Compliance.

        i. Contractor shall supply Certificates of Compliance for all Deliverable Materials and products.

        ii. Certificates of Compliance shall demonstrate proof of compliance of Materials with Contract requirements for each lot of material delivered.

        iii. If a collection of similar Equipment is certified, this lot shall be clearly identified by the Certificate of Compliance.

        iv. Contractor shall ensure certificates are signed by an authorized representative of the producer or manufacturer to indicate that the material complies in all respects with indicated Contract requirements.

        v. Certificates of Compliance shall be provided regardless of whether Materials or subassemblies are Commercial Off-the-Shelf (COTS), configured, or custom-made.

        vi. In the case of multiple shipments, each shipment shall be accompanied by a Certificate of Compliance.

        vii. The Certificate of Compliance shall be accompanied by a certified copy of test results.

        viii. The Certificate of Compliance shall give the information specified for submittals, the name and address of the organization performing the tests, the date of the tests, and the quantity of material shipped.

        ix. SFMTA reserves the right to refuse to permit the use of Materials based on an insufficient Certificate of Compliance.

    b. Contractor's procedures for receiving, handling, storage, and control of Materials and Equipment.

    c. Plans and procedures for source inspection and First Article Tests.

    d. Description of requirements and activities including process for Hardware and installation Drawing quality control.

    e. Description of the Configuration Control process and critical requirements to be followed to ensure integration to SFMTA operations and change control procedures.

f. Criteria and Control for Material Purchasing:

i. Contractor shall outline the criteria and methods to be used for the selection and management of Subcontractors and Suppliers.

ii. Contractor shall be responsible for ensuring that all supplies and services procured conform to Contract requirements.

iii. Contractor shall verify compliance to the accepted QAPP by Subcontractors and Suppliers and include appropriate flow down provisions in each of its lower-tier subcontracts for all quality-related requirements herein and those that support Reliability, Availability, and Maintainability, and safety.

iv. Contractor shall review and assess Subcontractor quality functions at intervals consistent with product complexity and quality requirements, but not less than annually.

4. Contractor shall supply SFMTA with Installation Specifications which include the quality requirements, specifications, and Standards for SFMTA to provide and enforce with its Installers.

5. Contractor shall ensure Installation Specifications require all purchased Materials, Equipment, and services to comply with Contractor's material, quality, workmanship, and performance criteria

6. Contractor shall identify in submittals to SFMTA all sources from which Contractor proposes to obtain Materials requiring SFMTA approval, certification, or testing.

7. SFMTA reserves the right to inspect, at the source or at the Site, any supplies furnished, or services rendered under the Contract. Contractor shall include in any agreements with its hardware or Equipment vendors SFMTA's right to contact hardware or Equipment vendors to discuss support, design, or quality issues. SFMTA shall coordinate with Contractor regarding any action required due to discussions with Contractor's vendors.

8. SFMTA will provide all Installer-produced documentation to Contractor for review.

9. Contractor shall verify compliance of Installer-produced documentation with its Installation Specifications. Contractor shall submit to SFMTA evidence of this verification as part of the turnover documentation.

10. A process to inform SFMTA of work in progress non-conformances as described in Section 5.5.8.

11. Materials Control Process

a. Contractor shall implement written Material Control procedures to ensure all purchased Materials whether used in Contractor manufacturing processes or as direct Deliverables for the Project conform to Contract requirements.

i. Procedures shall include Contractor's inspection prior to delivery; receipt inspection; evaluation of production facilities; and review of material certifications, Quality Assurance manuals for Suppliers of systems, and procedures.

ii. Procedures shall describe qualification and acceptance of Materials requirements for Suppliers.

iii. Procedures for identification and control of products.

iv. Procedures for how material is handled, stored, and shipped properly to prevent damage and loss.

b. Instructions for serialization and part identification, precautionary signs, protection against weathering and corrosion, drying agents, moisture barriers, and control of shelf life.

c. Contractor shall submit written Non-Conformance procedures to prevent use of items that do not conform to this specification.

i. Procedures shall include instructions on how to identify and document noncompliance.

ii. The procedures shall instruct Contractor staff to segregate noncompliant parts, notify the affected organizations and initiate corrective action.

iii. Contractor shall tag, document, and segregate defective items in a holding area pending disposition.

d. If SFMTA suspects defective Project work has occurred or defective Materials have been used, Contractor shall Furnish the labor, Equipment, and other resources needed to inspect the suspect work, Equipment or Materials, and correct any defects found, including issuing a Non-Conformance Report (NCR) if defect is found.

e. Contractor shall reimburse SFMTA for costs incurred by SFMTA staff and resources supporting the identification and corrective action of non-conforming work.

f. If the NCR has a disposition of "Repair" accepted, the Materials may be repaired. Contractor shall correct Materials damaged during building, assembly, installation, testing, or shipment at no expense to SFMTA.

g. Contractor shall document all repaired Materials by including the description of the repair and the repair completion date on the NCR.

h. Repair procedures shall be subject to approval prior to conducting the repairs.

12. Manufacturing and Process Control

a. Contractor shall establish written procedures to control Contractor's manufacturing, building, assembly, installation, and production of all Equipment and Materials provided for the Project.

b. Contractor shall establish workflows and control/ hold points for inspections, examinations, and tests of material and Equipment to prevent out-of-sequence activities.

i. Contractor shall establish processes such that no Project work will be covered over by a succeeding assembly prior to inspection or test.

ii. For items installed out of order, Contractor shall submit a plan for inspection and testing prior to commencing such activities.

iii. Contractor shall inspect, and test items installed out of order or found covered by succeeding assemblies to provide the same assurance as the inspection and test plan requires.

c. Manufacturing and production processes shall be performed by certified staff using qualified procedures under specified environmental conditions.

d. Contractor and Subcontractors shall implement quality control procedures to assure compliance with Project requirements.

e. Contractor and Subcontractors shall cite in their procedures, Drawings, and checklists applicable Codes, Standards, regulations, and acceptance criteria for special processes and tests.

f. Copies of staff certifications required for any special skills or techniques shall be included in the manufacturing or inspection plans, as applicable.

5.4 QUALITY ASSURANCE ASSESSMENT AND COMPLIANCE

5.4.1 ASSESSMENT OF QUALITY ASSURANCE PROGRAM

1. SFMTA shall have the right to visit facilities of Contractor and Subcontractors to assess the QA and QC activities of the Project.

2. During the QA and QC assessment, SFMTA may inspect production facilities, examine operations in progress, and review documentation. If deficiencies are noted by SFMTA, Contractor shall document such deficiencies and manage corrective action through Contractor's Failure Reporting and Corrective Actions System to ensure that corrective actions are accomplished and verified.

3. Contractor shall develop and perform corrective measures and documentation of the completed corrective action for SFMTA review and approval.

4. These oversight functions shall confirm that all Deliverables under the Contract, and accepted Contractor Drawings and documentation, conform to this specification.

5.4.2 SFMTA OVERSIGHT

1. The SFMTA's right to audit Contractor's records includes QA/QC records.

2. The SFMTA may audit or perform oversight evaluations of Contractor's, Subcontractors', and Suppliers' quality records and QA/QC performance.

3. Contractor shall respond and take corrective action to correct any deficiencies in Contractor's QA/QC program that SFMTA discovers.

4. Contractor shall ensure that all quality records and places of Work are open and available for inspection at all times.

5. When convenient, the SFMTA will give Contractor 10 Days' notice of intent to inspect or audit specific activities or installations. However, Contractor shall allow SFMTA to perform evaluations and audits at will and without notice if the SFMTA so requests.

6. Contractor, Subcontractor, Supplier staff performing the Work, Contractor's Quality Manager, and staff having responsibility for performing inspections or tests on the Work being evaluated shall be available during SFMTA's inspection.

5.4.3 QUALITY ASSURANCE REQUIREMENTS

5.4.3.1 QUALITY MANAGER

1. Contractor shall assign a Quality Manager to manage the quality of all Work activities and provide management and oversight of all ongoing quality functions being performed by Contractor and its Subcontractors and Suppliers.

2. Contractor shall develop and implement an organizational management structure providing the Quality Manager an independent management reporting path to the Contractor's executive leadership which is separate from the management of the Project Manager.

3. The Quality Manager shall have the organizational objectivity and authority to evaluate problems and verify resolutions, and to order rework or replacement of non-conforming Work.

4. The Quality Manager shall have the authority to issue a stop work notice if Work does not meet the Contract requirements.

5. The Quality Manager shall enforce compliance with all QA/QC Codes and Standards specified in Section 7 (Codes and Standards).

5.4.3.2 DESIGN CONTROL

1. Contractor shall establish phased quality reviews that provide incremental evaluation of compliance to the Contract and design requirements.

2. Contractor shall develop independent conformance checklists to verify:

    a. Design reviews demonstrate traceability between the System Design Documents and the Contract requirements.

    b. Design inputs from these Specifications, regulatory requirements, industry codes, and other referenced Standards are identified and documented.

    c. Procedures for translating design inputs into System Design Documents, Construction Documents, Drawings, and calculations have been completed.

    d. Independent quality checks on the System Design Documents, Construction Documents, Drawings, and calculations have been completed.

    e. System and Subsystem Requirements Documents, System Design Documents, and Construction Documents are the basis for purchase, manufacture, fabrication, test, inspection, and quality Standards of Contractor and Subcontractors.

    f. The CBTC Change Control Process as described in Section 15 has been used to review and approve all design changes and any direct or indirect impact has been reviewed and assessed before change is implemented including safety analysis/assessments.

    g. Contractor and Subcontractor procedures for document control have ensured that the latest versions of documents are available wherever they are needed, and that obsolete documents are marked as superseded and restricted to prevent their inadvertent access.

    h. Design changes comply with all requirements of these Specifications.

5.4.3.3 CONFIGURATION MANAGEMENT

1. Contractor shall submit to SFMTA a Configuration Management Plan (CMP) [CDRL] covering the Procurement Term that maintains and manages the Configuration of Equipment, Software, Hardware, plans or other designs.

2. Once approved, Contractor shall implement the CMP and ensure that requirements for changes are met and that any obsolete design documents and manuals are promptly removed physically and electronically.

3. Contractor shall propose methods and tools to manage and track Configuration changes and provide access and training of these methods and tools to SFMTA.

    a. All changes to infrastructure Configurations that are in a production environment shall be submitted to SFMTA TSI review and approval and are subject to the Change Advisory Board process described in Section 15.3 (Technology Change Advisory Board Procedures).

4. At a minimum, the Configuration Management Plan shall specify the following:

    a. Definition of Configuration control and management of Configuration items.

    b. Processes and procedures for Configuration management control of Software, firmware, and Hardware.

    c. Established Configuration baselines.

    d. Version control at the System, subsystem, module, and component levels in the Configuration Data List (CDL).

    e. Management of Configuration change requests, including a process for handling these requests, and committed times to respond and close requests.

    f. Processes and plans to meet Configuration related Contract requirements specified in this Section.

    g. Verification, validation, review, and audit of Configuration management activities.

5. Prior to Final Acceptance, Contractor shall submit evidence that all Software installed on the Project is the most current Software version installed or in use in all components or Hardware.

6. Upon Revenue Service in each Deployment Phase, all Software and Hardware used in the System shall be of the same version and/or revision, unless otherwise expressly permitted in writing by the SFMTA Project Manager.

7. Contractor shall submit recommendations to manage Hardware version requirements in Contractor's Obsolescence Management Plan.

8. Contractor shall maintain the Configuration of Software for the entire Procurement Term at no additional cost.

9. Contractor shall change the Software Configuration at SFMTA's request and respond within a reasonable time to all SFMTA Configuration change requests.

10. Contractor shall submit documentation for the control of Configurable Software settings to SFMTA prior to Final Acceptance.

5.4.3.4 NON-CONFORMING MATERIAL AND WORK

1. Contractor shall submit written procedures for control of non-conforming material, including procedures for identification of Material, segregation of Material, identification of Root Cause of the non-conformance, and final disposition of the Material.

2. Contractor and SFMTA shall jointly evaluate and determine disposition and corrective action for non-conforming Material.

3. All non-conforming Material shall be positively identified to prevent unauthorized use, shipment or mixing with conforming Material.

4. Contractor shall establish holding areas and other control methods as necessary to segregate non-conforming items from being used in the System.

5. Contractor shall also document non-conforming Work in the same manner as described in this Section.

6. Disposition to "Use As Is" (temporarily or permanently) or to "Repair" non-conforming Material or work shall require SFMTA authorization in Contractor's Non-Conformance Report (NCR) form.

7. Contractor shall present corrective action statements for all documented discrepant Material or activity so that recurring non-conformance will be prevented.

8. Contractor shall ensure that all corrective actions directives made to Subcontractors, Suppliers, and Installers are completed. Contractor shall report all noncompliance to SFMTA.

5.4.3.5 QA/QC RECORD KEEPING

1. Contractor shall develop written procedures to verify that QC records demonstrate compliance with requirements of the Installation Specifications.

2. These procedures shall include a QA/QC records list that identifies which records will be kept and who has responsibility for preparing, collecting, maintaining, storing, and disposing of them according to a specified quality records retention policy.

3. The QA/QC records list shall include results of examinations, inspections, tests, process controls, certification of processes and staff, non-conformances (including disposition), calibrations, corrective action, audits, and any other quality requirements specified by the Contract.

4. Contractor shall control its records, findings and transmittal letters with an electronic document control system. SFMTA shall have access to this system.

5. Contractor shall post in a visible place, any exceptions or notices to the quality of workmanship taken by SFMTA on any CBTC Equipment, System, or component in any location where Work on this CBTC Equipment, System, or component is performed. Contractor shall keep these notices current so Contractor staff can identify exception throughout manufacturing.

5.5 QUALITY CONTROL FUNCTIONS

1. Contractor shall inspect and verify Equipment for compliance with Contract requirements at Contractor's facilities or at its Subcontractor's facilities.

2. Contractor shall inspect Equipment stored at SFMTA's and Contractor's local facilities to assess transportation damage to Equipment.

3. Contractor's QA Manager shall respond and provide an explanation of any deficiencies in Contractor's Equipment that SFMTA or Contractor discovers. Contractor shall resolve such matters before shipment of affected items.

4. Contractor shall employ sufficient qualified staff to perform effective QC; Contractor's QC activities will be subject to evaluation and audit by SFMTA.

5. Contractor's QC activities shall include the development and execution of written procedures for the enforcement of receiving, source, in-process, first article, final, and acceptance inspections and tests, as described here and in Section 31.

6. Contractor's QC shall verify and document completion status of any approved retrofits or changes to Equipment or Materials.

7. Contractor shall ensure that products are manufactured correctly, marked with appropriate identification, successfully tested, and packaged in accordance with manufacturers' requirements to prevent damage during shipment.

8. SFMTA may conduct inspections of completed or in-progress items with, without, or in addition to Contractor's inspection, which does not waive or amend obligation to conduct thorough inspections.

9. SFMTA reserves the right to reject Materials and workmanship which do not fully conform to Contract requirements and approved designs. If SFMTA has rejected more than five (5) items from the same facility within a calendar month, Contractor shall stop Work at that facility. Contractor shall not resume Work until directed by SFMTA.

10. Contractor shall identify in the Project Schedule witness and hold point inspections for use by SFMTA. Output from the Baseline and Update Progress schedule shall be used to confirm SFMTA and Contractor QC witness activities.

5.5.1 INSPECTION AND TESTING

1. Contractor shall deliver an Inspection and Test Program Plan (ITPP) [CDRL], including procedures and reports to SFMTA.

2. The Inspection and Test Program Plan shall contain the Master List of all Inspections and Testing to be completed on the Project.

    a. Contractor shall track the development, submission and approval of all inspection and test procedures and reports.

    b. Contractor shall maintain a schedule of all inspection and testing as part of the Project Schedule. Contractor shall filter out other items from the inspection and testing view for presentation.

c. Contractor shall submit a status of all Inspection and Test Programs document Deliverables and the planned dated for conducting the inspections or tests in the Monthly Report.

3. The ITPP shall describe and explain the control and disposition of Contractor's inspection, testing and reporting records.

4. All testing activities and testing plans described in these Contract Specifications and specifically in Section 31 (Testing and Commissioning) shall be included in the ITPP.

5. All inspections and tests shall demonstrate compliance with these Contract Specifications and other applicable requirements and confirm elimination of deficiencies.

6. Test failures and failures to comply with inspection and testing requirements shall be subject to corrective action including non-conformance reports and other QC escalation and resolution.

7. Contractor shall provide QC inspection and testing personnel or will separate from and will not participate in Project production of the Work.

8. Contractor shall identify and describe the organization to be used for QC inspection and testing in the ITPP.

9. SFMTA may at anytime monitor the Work in progress to ensure that tests are being performed and documented in accordance with accepted procedures.

10. The ITPP shall describe and establish the inspection and testing provisions of the Project, with reference to the Test Program Plan described in Section 31 (Testing and Commissioning) and how it interfaces with the overall QAPP.

11. After SFMTA approval of the ITPP and the referenced Test Program Plan, any proposed changes will require approval by SFMTA prior to implementing the change.

5.5.2 TEST EQUIPMENT FOR INSPECTION AND MEASURING

1. Contractor and Subcontractors shall maintain inspection and testing equipment in satisfactory operating condition, of adequate capacity and range, and accurately calibrated at the frequency recommended by the equipment manufacturer.

2. Contractor and Subcontractors shall calibrate inspection and testing equipment in accordance with the National Institute of Standards and Technology (NIST) standards.

3. Contractor shall recalibrate inspection and test equipment when calibration discrepancy evidence exists.

4. Contractor and Subcontractors shall implement written procedures to ensure tools and inspection and test equipment are accurately calibrated.

5. Contractor and Subcontractors shall specify the tools and fixtures to be used as a medium of to inspect and test the Work.

6. Contractor shall calibrate all equipment within the manufacturer recommended calibration interval. Where no recommendation is provided, the calibration interval shall not exceed a year apart.

7. Calibration status shall be labeled on the controlled item and recorded to ensure adherence to calibration schedules.

8. Calibration labels shall identify the date of the most recent calibration, who performed the calibration, and when the next calibration is due.

5.5.3 INSPECTION AND TEST STATUS

1. Contractor shall submit written procedures to identify the inspection and test status of Project work during production and installation. Contractor shall illustrate these procedures where necessary.

2. The procedures shall require that inspection and test reports be accompanied by photographs as needed to clarify and document quality issues.

3. Inspection status shall be identified by tags and stamps.

4. Contractor shall maintain a tracking system and procedures to identify acceptance, rejection, or non-inspection status of Materials and components. The procedures shall ensure that only Work passing the required inspections and tests is accepted.

5. Contractor, Subcontractors shall identify to SFMTA non-conforming items by physical segregation and status indicators such as markings, serialization, stamps, tags, and inspection records.

5.5.4 LEVELS OF INSPECTION

1. Contractor shall specify 100 percent or sampling inspection for discrete items of Work.

2. If sampling plans are proposed, Contractor shall submit complete details of the sampling plans for approval by SFMTA.

3. Contractor shall perform sampling procedures which determine Acceptable Quality Levels (AQL) or Average Outgoing Quality Levels (AOQL) under ANSI/ASQ Z 1.4 or Dodge Romig tables for attribute sampling, MIL-STD-414 ANSI/ASQ Z1.9 for variables sampling, or other comparable plan approved by SFMTA.

5.5.5 STATISTICAL QUALITY CONTROL

1. Contractor shall employ the use of statistical methods including acceptance sampling, statistical process control, and traditional statistical methods to audit and accept Materials and to evaluate the performance of processes, as approved by SFMTA.

2. If used, Contractor shall perform such methods using published guidelines specified in Section 7.

3. Contractor shall use both traditional Shewhart-style Statistical Process Control (SPC) charts and short-run statistical process control techniques, where applicable.

4. Contractor shall present a list of Parts and Material to be inspected by Statistical QC Methods [CDRL].

5. Contractor shall document results as specified in the accepted process.

5.5.6 RECEIVING INSPECTION AND SOURCE INSPECTION

1. Contractor shall develop and implement written procedures to ensure items are inspected at source of manufacturing as well as upon receipt, to verify conformance to acceptance criteria of this specifications and Contract Drawings.
2. All inspections shall be performed to Contract requirements and Specification requirements herein.
3. Contractor shall retain all material certifications and test reports.

5.5.7 FIRST ARTICLE CONFIGURATION INSPECTIONS

1. Contractor shall perform First Article Configuration Inspections (FACI) as required in Section 31.

5.5.8 INSPECTION OF WORK IN-PROGRESS

1. Contractor's Quality Manager shall maintain and direct its force of inspectors, independent of production, to verify that Work in its manufacturing shops is performed in compliance with the accepted design Drawings. This QC verification is required in addition to any QC checks and corrections by the production workforce.
2. Contractor shall manage inspection non-conformances in the Work, by recording such non-conformances and notifying in writing to the departments responsible for the Work the need for corrections.
3. Contractor shall develop and implement a process to inform SFMTA of work in progress non-conformances.
4. Contractor shall notify SFMTA of any non-conformances. SFMTA will propose and execute agreement for the disposition of any non-conformances.
5. Contractor and Subcontractors shall not release non-conforming Materials until all discrepancies have been corrected, or a corrective action plan has been proposed by Contractor and agreed by SFMTA.
6. Contractor shall inspect repairs and corrections for conformance to Drawings and accepted rework instructions, as needed.
7. Contractor shall submit documentation of re-inspection status.
8. Contractor shall notify SFMTA of all inspections and SFMTA may observe or audit inspections at any time.

5.5.9 HOLD POINT INSPECTION

1. Contractor shall establish hold points in the delivery processes to provide critical inspections.
2. Hold points shall be utilized to inspect in-progress installations and completed Project work.
3. Hold points shall also be used to inspect items that are about to be covered by succeeding assembly operations.
4. Contractor shall submit a list of hold point inspections to SFMTA for approval.
5. Hold points shall be clearly identified in the Project Schedule.

6. In any instance where established hold point criteria are not met, SFMTA shall have the right, to direct quality control mitigation measures to Contractor. These mitigation measures may include but are not limited to stopping shipment, stopping Deployment, implementing a recovery plan, or other Work that will mitigate the hold point failure. Contractor shall not have any additional cost or schedule entitlement due to these directed mitigation measures.

5.5.10 PRE-SHIPMENT TESTING

1. Contractor shall test all material at the manufacturing site to ensure compliance with Contract requirements.
2. Contractor and Subcontractors shall perform pre-shipment tests according to approved procedures.
3. Contractor and Subcontractors shall document results and capture and store test artifacts.
4. Contractor shall take corrective measures and repeat tests until successful.
5. Final inspection, shipment, installation, or Deployment shall not be permitted until testing is successfully completed and accepted, and results documented.

5.5.11 FINAL INSPECTIONS PRIOR TO SHIPMENT

1. Contractor shall submit advance notification of at least fourteen (14) Days to SFMTA as to when final inspections will take place.
2. Contractor shall schedule a minimum of one Day for SFMTA's inspection of any major assembly before each shipment.
3. After all Work is completed, Contractor shall perform final inspection according to approved procedures.
4. Contractor and Subcontractors shall correct workmanship items covered by prior inspection reports before final inspection begins.
5. Contractor shall provide a qualified supervisor to accompany SFMTA during final inspection to assure that proper corrective action is taken.
6. During final inspection, all systems shall be operational with use of approved types of special equipment or power supplies.

5.5.12 SHIPPING INSPECTION

1. Contractor shall prepare written procedures to ensure completion of manufacture prior to shipment from each manufacturing facility, and that all shipments are adequately prepared to preclude damage during shipment.
2. These procedures shall include assembly, shipping, and preparation instructions and inspection procedures for assemblies scheduled for shipment to the next manufacturing facility or acceptance site.

5.5.13 RETROFIT INSPECTION

1. Contractor shall submit written procedures to inspect retrofits or changes made to the CBTC System on SFMTA property.

2. When a retrofit or change is initiated, Contractor shall list all part(s) impacted by location / subsystem and implement retrofit or change at every location including parts in storage and spares.

5.5.14 QUALITY MANAGEMENT REPORT

1. Contractor shall develop a Failure Reporting and Corrective Action System (FRACAS) and process to monitor the CBTC System during Operations as described in Section 30.2.2 (Failure Reporting and Corrective Action System).

2. Contractor shall develop a Quality Management Report (QMR), [CDRL] demonstrating evidence of Quality Management in accordance with Section 5.2 of EN50129:2018 in support and as part of the Final Safety Report (FSR) described in Section 6.

5.6 QUALITY ASSURANCE AUDITS

5.6.1 GENERAL

1. Contractor shall conduct internal QA audits according to its documented procedures and audit plan to ensure that its quality System is functioning as required.

2. Contractor shall document audits and follow-up actions as evidence that corrective actions are taken by responsible persons in Contractor organization.

3. Audits shall be performed using approved checklists.

4. Audits shall be performed by staff other than those who performed the Work.

5. Contractor shall provide SFMTA access to internal Contractor and Subcontractor audit reports which concern any Work.

6. SFMTA will audit Contractor’s QA activities to determine compliance with the approved QAPP. During audits of Contractor's QA functions, SFMTA reserves the right to audit the QA programs of Subcontractors.

7. SFMTA will notify Contractor of any non-compliance found during audits.

8. Non-compliance with any part of the approved QAPP shall be cause for rejection of all affected Project Deliverables.

9. SFMTA may allow Work to continue either in whole or incrementally as Contractor implements corrective actions. SFMTA may at any time rescind this permission and stop Work. Contractor shall immediately correct identified non-compliances, at no additional cost, if SFMTA stops Work due to non-compliance.

10. After corrective action of the non-compliance has been verified by SFMTA, SFMTA shall notify Contractor on the NCR form. Work may resume after verification.

11. Schedule delays caused by non-compliance with the accepted QAPP shall not be the basis for requesting an extension of time or cost claim under the Contract.

12. Audits shall report on the compliance to the accepted QAPP and with the QA procedures.

5.6.2 AUDITS OF CONTRACTOR

1. SFMTA may audit Contractor's QA program at any time, but specifically during the following times:
    a. Prior to production of major CBTC Equipment assemblies and subassemblies.
    b. After completion of major CBTC Equipment assemblies and subassemblies but before shipment and installation of Equipment
    c. After installation of CBTC Equipment assemblies and subassemblies onto SFMTA property
    d. During CBTC System testing and Commissioning
    e. Any time prior to use of CBTC Equipment assemblies and subassemblies in Revenue Service operation; and
    f. Any time SFMTA determines an audit to be appropriate due to trending in non-conformances

5.6.3 CONTRACTOR AUDITS OF SUBCONTRACTORS, MANUFACTURERS AND INSTALLERS

1. Contractor is responsible for the quality of all Work under the Contract.
2. Contractor shall perform Quality Assurance audits on its Subcontractors and Suppliers.
3. Contractor shall perform Quality Assurance audits on SFMTA Installers upon SFMTA request.
4. Contractor shall notify SFMTA in advance of any scheduled audit. Audits of the Subcontractors may be witnessed by SFMTA.
5. An audit schedule shall be submitted as part of the QAPP.

5.6.4 AUDIT REPORTS

1. Audit reports shall be submitted as follows:
    a. Following SFMTA audits, SFMTA may provide Contractor with a report of each audit within 10 Days of completing the evaluation.
        i. The audit report will describe the scope of the audit and procedures followed.
        ii. The audit report will identify any deficiencies, including non-conformances and/or corrective actions, and date when corrective action for each deficiency/non-conformance is required.
        iii. Contractor shall respond to corrective action requests issued by SFMTA within 10 Days of receiving the evaluations indicated in the corrective action request form.
    b. Within one week following any Contractor audit, Contractor shall submit a formal written Quality Audit Report [CDRL] of the audit describing the scope of the audit and procedures followed. The audit report will identify any deficiencies, including non-conformances and/or corrective actions, and date when corrective action for each deficiency/non-conformance is required.

5.7 QUALITY ASSURANCE AND QUALITY CONTROL CDRLS

Table 5-8: Quality Assurance and Quality Control CDRL Table

CDRL #	CDRL Title
5.01	Quality Assurance Program Plan (QAPP)
5.02	Confirmation of Subcontract Quality Assurance
5.03	Quality Assurance Manuals
5.04	Software Quality Assurance Plan (SQAP)
5.05	Hardware Quality Assurance Plan (HQAP)
5.06	Configuration Management Plan (CMP)
5.07	Inspection and Test Program Plan (ITPP)
5.08	Parts and Materials to be inspected by Statistical QC Methods
5.09	Quality Management Report
5.10	Quality Audit Report

6 SYSTEM SAFETY AND SECURITY MANAGEMENT

6.1 PURPOSE

1. This Section provides System Safety and Security Management requirements to ensure the CBTC System will meet California Public Utilities Commission (CPUC) General Order 127 (Maintenance and Operations of Automatic Train Control Systems) requirements. This Section consists of three major Subsections:

    a. Safety and Security Certification

    b. System Safety

    c. System Security

2. The activities specified throughout are intended to build the foundation for achieving overall safety and security certification required for Revenue Service operations.

6.2 SAFETY AND SECURITY MANAGEMENT REQUIREMENTS

1. Contractor shall develop plans and apply processes and guidelines according to Safety and Security Management Guidance for Major Capital Projects (FTA C 5800.1) and in compliance with applicable FTA guidelines, notably FTA Handbook for Transit Safety and Security Certification (FTA-MA-90-5006-02-01).

2. Contractor shall develop and perform its safety and security processes and activities according to SFMTA's Safety and Security Management Plan (SSMP).

3. Contractor shall provide the SFMTA with all documentation necessary to obtain CPUC safety and security certification for the System applying General Order 127 -ATC for Rapid Transit Systems, General Order 164-E – State Safety Oversight for Rail Transit, and General Order 175-A – Roadway Worker Protection.

4. Contractor shall submit additional information and documents as required by SFMTA in preparing a Safety and Security Certification Verification Report (SSCVR) as described in the SSMP. SFMTA may hire an Independent Safety Assessor (ISA) to oversee Contractor's System safety and certification activities.

5. Contractor shall develop a Safety and Security Certification Plan (SSCP) [CDRL] that provides the framework, workflow, and compliance necessary to achieve CPUC certification requirements.

6. The SSCP at a minimum shall include the following:

    a. CBTC Safety and Security Certifiable elements and items list.

    b. Description of CBTC safety and security roles, responsibilities, and committees to be established. Contractor shall describe all Contractor, Subcontractor and SFMTA specific roles and responsibilities.

    c. CBTC Safety and Security Design Criteria.

    d. CBTC Design Criteria Conformance Checklist.

e. CBTC construction checklist verifying that construction, manufacturing, and installation are carried out in accordance with the design.

f. CBTC tests checklist to verify the functionality of Contract specification tests and the integration interface between involved systems or Equipment.

g. The development, review, and implementation of training programs, training and supporting Materials required for SFMTA staff including required operational competencies including safety, security, and emergency preparedness.

h. The processes governing the development identification, tracking, resolution, and Acceptance of the Threat and Vulnerability Tracking List [CDRL].

i. The process to manage and track "Open Items" that have not been verified for conformance with safety and security design requirements as well as unresolved safety and security issues.

j. The process roadmap, inputs, approvals, and artifacts required to achieve "Certification of Safety and Security".

6.2.1 SAFETY AND SECURITY DESIGN CRITERIA DEVELOPMENT

1. Contractor shall develop CBTC safety and security design criteria based on the Hazard analyses, security assessments, applicable Codes, Industry Standards, and lessons learned from the development of similar operating systems.

2. Contractor shall submit the Safety and Security Design Criteria [CDRL] for SFMTA review and approval at the Conceptual Design Review.

6.2.2 SAFETY AND SECURITY DESIGN CRITERIA CONFORMANCE CHECKLIST

1. Contractor shall submit a Safety and Security Design Criteria Conformance Checklist [CDRL] based on the certifiable safety and security elements specified by Contractor in their SSCP.

2. Contractor shall reference the SSMP in the development of the Safety and Security Design Criteria Conformance Checklist.

3. The Safety and Security Design Criteria Conformance Checklist shall list and reference all safety and security requirements from the SSMP, SSCP and Contract Specifications for use in Design Reviews.

4. Contractor shall document full traceability of the System and Contract requirements to the Safety Design Criteria Conformance Checklist and provide documentation to SFMTA.

6.2.3 SAFETY AND SECURITY CONSTRUCTION SPECIFICATION CONFORMANCE CHECKLIST

1. Contractor shall submit at the Conceptual Design Review, a Safety and Security Construction Specification Conformance Checklists [CDRL] based on the certifiable Safety and Security Certifiable elements Contractor identified in the SSCP.

2. Contractor shall use the SSMP as a guideline in the development of the Safety and Security Construction Specification Conformance Checklists.

3. The Safety and Security Construction Specification Conformance Checklists shall:

a. Identify the tests and verification methods necessary to ensure that the completed System meets the safety and security requirements identified in the Safety and Security Design Criteria Conformance Checklist, and

b. Provide documentation that the completed System meets those requirements.

c. Verify the CBTC System construction, manufacturing and installation are carried out in accordance with the safety and security requirements identified in the Safety and Security Design Criteria Conformance Checklist.

d. Contractor shall submit documentation verifying that all installation, construction, or other Project implementations and training meet all safety-critical requirements including Hazard analysis mitigations, System requirements, and design criteria.

6.2.4 SAFETY-RELATED AND SECURITY TESTING CONFORMANCE CHECKLIST

1. Contractor shall submit a Safety-Related and Security Testing Conformance Checklist [CDRL] based on certifiable safety and security elements required to obtain CPUC approval and certification of the CBTC System.

2. The Safety-Related and Security Testing Conformance Checklist shall validate Contractors' safety related and security testing approach and methodology, specific witness requirements, and test pass/fail criteria to determine whether there is a need for additional safety and security testing.

3. A formal Test description sheet shall be submitted by Contractor at the Preliminary Design Review, describing the safety-related and security test procedure(s), test prerequisites, testing resources required, time required, designated test witnesses, and the specific safety and or security requirements (including internal and external interface related requirements) being verified/validated by each procedure.

6.2.5 SAFETY AND SECURITY RULES, PROCEDURES, TRAINING AND DRILLS CONFORMANCE CHECKLIST

1. Contractor shall submit a Safety and Security Rules, Procedures, Training and Drills Conformance Checklist [CDRL] based on certifiable items, at the Final Design Review.

2. Contractor shall follow the guidelines outlined in the FTA Handbook for Transit Safety and Security Certification (FTA-MA-90-5006-02-01).

3. The Safety and Security Rules, Procedures, Training and Drills Conformance Checklist shall verify that:

   a. The CBTC safety and security operations, maintenance, and emergency rules, procedures, and plans have been developed, reviewed, approved and implemented,

   b. The CBTC Manuals showing how to operate and maintain safety and security systems, Equipment and facilities have been developed, reviewed, approved, and provided to SFMTA prior to the start of any safety and security training,

   c. The safety and security training for operations and maintenance personnel (including train-the-trainer program) has been developed, performed, and successfully completed by all designated CBTC personnel and trainers as required,

d. CBTC emergency training has been developed, performed, and successfully completed by all designated personnel as required, including public safety personnel (if appropriate). The CBTC emergency training covers instances where management of an emergency requires interaction with CBTC Systems/subsystems,

e. CBTC Emergency drills and training have been reviewed by SFMTA:

i. To familiarize and train emergency response personnel in CBTC-related emergency procedures,

ii. To evaluate response procedures,

iii. To ensure CBTC procedures are in line with and integrated with SFMTA's current procedures and rulebook or to verify that any update required to SFMTA's procedures have been properly implemented,

iv. To identify and implement improvements to response procedures before a real emergency occurs,

v. To maintain a high level of emergency response readiness.

vi. Operational readiness review has been completed.

6.2.6 HAZARD RESOLUTION CONFORMANCE CHECKLIST

1. Contractor shall submit a Hazard Resolution Conformance Checklist [CDRL] based on Hazard analyses and security assessments to document that identified Hazards, threats and vulnerabilities have been satisfactorily mitigated by Contractor.

2. The Hazard Resolution Conformance Checklist shall be provided to SFMTA for Acceptance and approval at the Preliminary Design Review.

6.2.7 SAFETY AND SECURITY CERTIFICATION REPORT

1. Contractor shall submit a Safety and Security Certification Report (SSCR) [CDRL] to demonstrate that Hazards, security threats and vulnerabilities have been sufficiently mitigated by Contractor.

2. The Safety and Security Certification Report shall include:

a. A description of the CBTC System;

b. A brief description of the certification process undertaken;

c. A description of where certification documentation is located;

d. All signed Certifiable Elements certificates of conformance;

e. The CBTC System certificate of conformance, including restrictions;

f. A list of all "Open Items" including the safety/security impact(s) and workarounds to mitigate the impacts;

g. The process and schedule for closing out all "Open Items."

3. Contractor shall submit the final SSCR to SFMTA at least 40 days prior to start of Revenue Service for each Phase.

6.3 SYSTEM SAFETY

1. Contractor shall check that all System requirements and Deliverables which relate to System safety are in accordance with SFMTA procedures and protocols as described in the SSMP and its references.

2. Contractor shall include traceability to the SSMP and its references in the Requirements Traceability Matrix.

3. Contractor shall demonstrate that the CBTC System complies with applicable CENELEC Standards and IEEE Standards as specified in Section 7 (Codes and Standards). Alternatively, Contractor may propose other equivalent Standards subject to SFMTA review and approval.

4. Contractor shall demonstrate that any Hardware and/or Software deployed for the Project that impacts System safety has been safety certified prior to Deployment.

5. Prior to Deployment, product upgrades or other manufacturer recommended modifications shall be demonstrated to have no adverse impacts on the safety of the CBTC System that would invalidate the original Safety Certification.

6. Contractor shall develop and supply all safety certification related documents required to achieve full certification that the CBTC meets CPUC General Order 127 (Maintenance and Operations of Automatic Train Control Systems) requirements. Contractor shall provide all required documentation to support this certification to the SFMTA.

6.3.1 SAFETY PLANS, HAZARD ANALYSIS, MANAGEMENT AND RESOLUTION

1. Contractor shall develop safety plans and perform Hazard analysis as described in this Section 6.3.1 on the System and subsystems to identify, evaluate and address Hazards.

2. Contractor shall include CBTC related environmental Hazards, notably Hazards associated with seismic events in accordance with seismic requirements specified in Section 27, in its Hazard analysis.

6.3.1.1 SYSTEM SAFETY PROGRAM PLAN

1. Contractor shall develop a System Safety Program Plan (SSPP) [CDRL].

2. The initial SSPP shall be submitted at the Conceptual Design Phase.

3. Contractor shall submit an updated version of the SSPP at the Preliminary Design Review.

4. Contractor shall submit a final version of the SSPP at the Final Design Review.

5. Contractor shall develop the SSPP in accordance with IEEE 1474.1 (2004) Annex E.1 or an equivalent Standard subject to SFMTA's review and approval.

6. The SSPP shall include actionable activities, roles and responsibilities for the activities, processes detailing the inputs, outputs, and dependencies of CBTC safety Deliverables.

6.3.1.2 SOFTWARE ASSURANCE PLAN

1. Contractor shall submit the Software Assurance Plan (SAP) [CDRL] as part of the Preliminary Design Review package.

2. The SAP shall outline a plan for all Project Software development, implementation, verification, and validation, including testing, and Commissioning to comply with EN50128:2011/A2:2020 (or an equivalent Standard subject to SFMTA review and approval).

3. The SAP shall list the Software applications and packages which make up the Project Software environment.

4. The SAP shall describe how any Configuration of safety certified Software does not nullify the Safety Certification (i.e. Configuration can be made without violating safety cases).

5. The SAP shall describe how Contractor controls Software development and Configuration from design through final production.

6. The SAP shall describe how Software is deployed and how field data is safely captured, processed, and validated before Software releases.

7. The SAP shall describe how Software specific safety-related and safety-critical requirements are captured and managed.

8. Contractor shall ensure that the objectives, dependencies and relationship between the SAP, Software Project Management Plan (SPMP), Software Quality Assurance Plan (SQAP) and System Safety Program Plan (SSPP), are clear and consistent. Contractor shall provide a summary of the alignment of these parameters in the Project Quality Program Plan.

9. The SAP shall have a safety requirements checklist for Software releases for field testing in coordination with the SSCP to achieve appropriate Safety Certification.

10. The SAP shall have a Software specific requirements checklist for Software releases for field testing in coordination with the SSCP to achieve Project functionality requirements.

6.3.1.3 SAFETY VERIFICATION AND VALIDATION PLAN

1. Contractor shall prepare a Safety Verification and Validation Plan (SVVP) [CDRL] describing the steps to be taken to produce the Safety Verification and Validation Report.

2. The SVVP shall describe how Contractor will verify and validate safety requirements during each of the Project implementation stages as depicted by EN50126-2017 Part 1 Figure 7 or according to equivalent Standard subject to SFMTA review and approval.

3. For safety certified products, Contractor shall describe in this plan on how safety requirements exported to the Project level will be verified and validated.

6.3.1.4 PRELIMINARY HAZARD ANALYSIS

1. Contractor shall submit the Preliminary Hazard Analysis (PHA) [CDRL] as part of Preliminary Design Review package in accordance with IEEE 1474.1 (2004) Annex E.2 or an equivalent Standard subject to SFMTA review and approval.

2. The PHA report shall include an analysis of the identified Hazards and risks, and the design features implemented to mitigate those risks; design goals and quantitative/qualitative analyses to support achieving those goals; industry statistical trends and lessons learned from the implementation of similar systems; Hazard severities; Hazard probabilities; and operational constraints.

6.3.1.5 SYSTEM HAZARD ANALYSIS

1. Contractor shall conduct a System Hazard Analysis (SHA) [CDRL] as specified in IEEE 1474.1 (2004) Annex E.4 or an equivalent Standard subject to SFMTA review and approval.

2. Hazards and mitigation identified at the PHA level shall be traced to the SHA for further assessment and breakdown.

3. The SHA shall be submitted as part of the Final Design Review package.

6.3.1.6 SUBSYSTEM HAZARD ANALYSIS

1. Contractor shall conduct a Subsystem Hazard Analysis (SSHA) [CDRL] in accordance with IEEE 1474.1 (2004) Annex E.3 or an equivalent Standard subject to SFMTA's review and approval.

2. The SSHA shall document the verification of safety compliance and identify Hazards associated with each subsystem such as zone controllers, onboard controller, data communication systems, as well as safety-critical and safety related interfaces. Safety-related and critical interfaces may be separately analysed in the Interface Hazard Analysis (IHA) report [CDRL] or as part of the SSHA. See Section 28 for details on external interfaces.

3. Contractor shall analyse all safety related interfaces and verify that they react in Fail-Safe manner whenever an external safety input is disconnected or otherwise not available.

4. The SSHA shall demonstrate traceability of Hazards from SHA.

5. The SSHA shall be submitted as part of the Final Design Review package.

6.3.1.7 OPERATING AND SUPPORT HAZARD ANALYSIS

1. Contractor shall conduct an Operating and Support Hazard Analysis (O&SHA) [CDRL] in accordance with IEEE 1474.1 (2004) Annex E.5 or an equivalent Standard subject to SFMTA's review and approval.

2. The O&SHA shall be submitted as part of the System Final Design Review package.

3. Contractor shall review current SFMTA procedures and guidelines provided in the Reference Materials and Appendix J to the Agreement and note changes between existing procedures and guidelines and proposed procedures and guidelines in the O&SHA.

4. Contractor shall conduct a human factors assessment in situations where the introduction of new CBTC System procedures and guidelines are a major change from existing operational and maintenance practices. Contractor shall include such human factors assessments in the O&SHA.

6.3.1.8 FAILURE MODES, EFFECTS, & CRITICALITY ANALYSIS

1. Contractor shall conduct Failure Modes and Effects and Criticality Analysis (FMECA) [CDRL], to identify and analyze single-point failure modes, and their combination at component based on credible failure modes specified by EN 50129 Annex C or equivalent.

2. Contractor shall design and submit a FMECA for all safety-related and Safety Critical Hardware. For components in the analysis carrying an existing SIL Certification level, and for which a SIL Determination/Verification included a FMECA, existing verification analysis documents (including the performed FMECA) may be substituted in the submittal.

3. The FMECA shall be submitted as part of the Preliminary and System Final Design Review packages.

4. Each FMECA shall, at a minimum, address the following:

    a. Single point Hardware failures as induced or simulated for all circuit components, their effects on the Hardware circuit, their effects on the overall System, their criticality, and the means by which the failure is detected.

    b. The FMECA shall address all modes of failure relevant to the component, including changes in the component value outside of normal tolerances, to verify that no single point failure shall be shown to cause an unsafe condition.

    c. The effect of all failure modes shall be classified to be self-revealing or not self-revealing (Dormant) as specified in EN 50129 Annex C.

    d. All combination of failures shall be shown to not result in unsafe condition, except for combination of simultaneous independent self-revealing failures.

    e. Failures that are not self-revealing (Dormant) shall be analyzed in all combinations with all other failures (excluding combination with two self-revealing failures). In the instance of a non-self-revealing failure, a subsequent failure cannot be considered as independent.

    f. If Contractor determines that analysis of non-self-revealing failure in combination with all other failures (excluding combinations with two self-revealing failures) is not required, Contractor shall document the reasons justifying this decision in the FMECA.

    g. Show that if any unsafe condition results from a combination of two or more failures, then those failures are independent and self-revealing.

6.3.1.9 FAULT TREE ANALYSIS

1. Contractor shall develop a System-level Fault Tree Analysis [CDRL] based on EN 61025:2011 or equivalent.

2. The Fault Tree Analysis shall be used to show compliance with the safety requirements listed in the Safety and Security Design Criteria Conformance Checklist.

3. Contractor shall demonstrate that the Fault Tree Analysis has correctly modeled the CBTC System starting from top level CBTC Hazards down to subsystem, component levels.

4. The Fault Tree Analysis, as a minimum, shall contain the following elements:

    a. A discussion of the analytic techniques used to generate the fault tree.

    b. Explanation of the types of faults considered part of the CBTC and those, which are external to the CBTC, if any.

    c. Fault Tree Analysis diagram developed from Safety and Reliability tool, accompanied with definition and description of the Boolean logic presented.

    d. Discussion and demonstration of independence of events and assessment of common causes if any.

e. Identification and discussion on the "minimal cut set" events and their contribution to the top Hazard.

f. Contractor shall reference the Reliability, Availability and Maintainability (RAM) requirements reused in the requirements analysis to augment the development of this analysis. The Fault Tree Analysis shall continue through to the lowest qualifiable base event level.

g. The Fault Tree Analysis shall be submitted as part of the Preliminary and System Final Design Review packages.

6.3.1.10 CUTOVER HAZARD ANALYSIS

1. Contractor shall conduct a Cutover Hazard Analysis (CHA) [CDRL]. The cutover of existing signaling to CBTC System introduces the potential of Hazards associated with the physical cutover and the System transition.

2. The CHA shall demonstrate that no Hazard is introduced due to either the process adopted during cutover, temporary connections or wiring changes, transitional or staged Software releases to account for interim track layout Configuration, or Phased functionality. This analysis should include design mitigations, procedures, trainings required to mitigate the identified Hazards.

3. The CHA shall identify Hazards-related operation and maintenance activities in the mixed mode environment where Train Operators and System maintainers are not fully transitioned to CBTC System and are required to switch between the legacy ATCS and CBTC ways of operation and maintenance during the System Procurement Term.

4. The CHA shall include a cutback analysis identifying Hazards in returning to the existing signaling following testing. This analysis should include design mitigations, procedures, trainings required to mitigate the identified Hazards.

5. The CHA shall be submitted as part of the System Final Design Review package.

6.3.1.11 HAZARD LOG

1. Contractor shall develop and maintain a Hazard Log [CDRL] capturing all identified Hazards applicable to the CBTC System being deployed including Hazard associated with the which the CBTC System interfaces.

2. Contractor shall submit the Hazard Log as part of as part of the Preliminary Design Review package.

3. Contractor shall update and resubmit the Hazard Log as part of as part of the Final Design Review package.

4. Contractor shall update and resubmit the Hazard Log at the Construction Final Design Review package for every Deployment Phase.

5. The Hazard Log shall identify the responsible party assigned to mitigate the Hazard and provide an auditable trail from initial identification of the Hazard to the point of adequate resolution.

6. Each dated entry shall note the measures that have been taken to either eliminate the Hazard or to minimize the Frequency and Severity of the Hazard for those which cannot be eliminated.

7. The Hazard Log as a minimum shall:

a. Contain SFMTA SSMP Hazard Log template attributes.

b. Provide traceability from identified mitigation to the corresponding safety requirements.

c. Remove repeated and duplicate Hazards through Hazard consolidation activity.

6.3.2 RISK ASSESSMENT AND MANAGEMENT

1. Hazard severity categories are specified in SFMTA's Public Transportation Agency Safety Plan (PTASP) for generic risks and the Hazard Severity Tables to provide a qualitative measure of the worst credible mishap resulting from personnel error, environmental conditions, design inadequacies, procedural deficiencies, System, subsystem or component failures, or malfunctions.

2. The Hazard Log shall demonstrate risk analysis and management to comply with EN 50126:2017 or an equivalent Standard subject to SFMTA review and approval.

3. Any Hazard with a Hazard severity of 1 or 2 (Catastrophic or Critical) as determined by Contractor and SFMTA during the Preliminary Hazard Analysis and according to the PTASP shall be designated as a Safety Critical Item and clearly identified as such in the Hazard Log.

4. Safety Critical Items shall require completion of the specific resolution actions prior to CBTC System operation.

5. Contractor shall mitigate Hazards by applying the System safety design order of precedence in accordance with IEEE 1474.1 (2004) Annex E.6 or an equivalent Standard.

6. All Hazards, after mitigation, shall be submitted to SFMTA for review. SFMTA will make the final determination to accept risk. SFMTA may determine certain risks remain unacceptable after mitigation, especially when the unacceptable risk is not totally eradicated and contains residual risk.

    a. Unacceptable residual risk must be mitigated by design including design of warning devices and procedures.

    b. Undesirable residual risk shall be further mitigated to "Acceptable with Review". Cost Benefit Analysis (CBA), or quantitative risk analysis type analysis shall be presented by Contractor, subject to approval of SFMTA should the cost of the mitigation be too costly to implement by Contractor according to EN 50126:2011 As Low As Reasonably Practicable (ALARP) principle.

    c. Acceptable with Review residual risk is subject to review and approval of SFMTA.

7. The Hazard Log shall demonstrate justification on the approach for residual risk determination based on EN 50126:2017 or an equivalent Standard subject to SFMTA's review and approval.

6.3.2.1 OTHER TYPES OF RISK ASSESSMENT

1. Contractor shall perform and document in the SSPP a risk assessment to show with a high probability that the introduction of Contractor's CBTC System will not result in risks that add, increase or exceed the current risk conditions that exist in SFMTA's operating environment (including conditions present in the existing ATCS). The risk assessment shall consider:

    a. Risks associated with the current conditions that are no longer present because of implementing the CBTC System.

b. New risks created by the CBTC System that are not present with the current conditions.

c. Risks neither newly created nor eliminated whose nature changes the probability of the risks, either better or worse, in SFMTA's existing operating environment.

2. The risk assessment procedures shall provide a quantitative measure for the existing system (legacy ATCS system) and new CBTC System.

   a. Risk shall be measured based on predicted frequency of Incidents and the severity of Incidents, with consideration of the track plan, number of Trains and movement density, operational rules, and human factor impacts.

   b. The same methodology and equivalent assumptions shall be used in both cases.

   c. The risk assessment shall also include a sensitivity analysis to show the sensitivity of the risk measures to the assumptions used.

3. SFMTA will work with Contractor to provide relevant and available historical operational data related to failures/faults of the existing wayside signal system that resulted or contributed to near misses, accidents/Incidents, environmental damage, passenger/personnel injury, or fatalities, to support Contractor's risk assessment for the existing ATCS.

4. Contractor shall provide a comparison of risks from Contractor's CBTC System design to the existing ATCS to indicate any risk similarities or conflicts.

5. Risk assessments shall be expressed in units of consequences per unit of exposure where exposure is expressed as total train miles traveled per year.

6. Consequences shall identify the total costs of accidents, including fatalities, injuries, property damage, and other incidentals costs, and are dependent on the frequency of Hazardous events and their severity.

6.3.3 SYSTEM SAFETY PERFORMANCE REQUIREMENTS

1. Contractor shall develop and provide assurances for System safety through an approach to safety Hazard analysis emphasizing the prevention of accidents by identifying and resolving Hazards in a systematic manner.

2. Contractor's design shall minimize the reliance on Standard Operating Procedures (SOPs) specified in Section 10.4 to mitigate Hazards when System safety design order of precedence is possible (such as Design, Use of Safety Devices, or Use of warning devices respectively).

3. Contractor shall implement a Fail-Safe design philosophy applied to safety related systems such that the result of Hardware failure or the effect of Software error is a safe state.

4. Contractor's design shall either prohibit the System from assuming or maintaining an unsafe state or shall cause the System to assume a state known to be safe.

5. Contractor shall establish quantitative safety performance requirements for the CBTC System. The target for the safety of the CBTC System is a total calculated aggregate Mean Time Between Hazardous Events (MTBHE) (total of all critical and catastrophic Hazards) of at least 1×10^9 operating hours, as required by IEEE Std. 1474.1. Performance requirements must consider the maximum number of other Trains that can be in this contiguous portion of a one-way route under the specified peak operating headway.

6. Contractor shall propose apportioned wayside and onboard MTBHE targets that could be achieved based on the safety performance requirements, number of Trains equipped, peak headway and wayside Equipment supplied.

6.3.4 SAFETY VERIFICATION AND VALIDATION REPORT:

1. Contractor shall prepare a Safety Verification and Validation Report (SVVR) [CDRL] in accordance requirements contained in the SVVP.

2. Contractor shall submit this SVVR at the beginning of Field Testing, start of any RAM Demonstration and at Commissioning.

3. Contractor shall demonstrate that the test activities carried out to verify and/or validate the safety requirements listed in the Safety and Security Design Criteria Conformance Checklist meet the following minimum criteria:

    a. Safety related test procedures shall evaluate and validate the expected safety behavior described by the applicable safety requirement (including negative testing, fault insertion.).

    b. Safety related test procedure(s) shall fully cover the safety requirements listed in the Safety and Security Design Criteria Conformance Checklist subject to SFMTA's review and approval.

    c. Safety related tests shall be carried out as specified in the procedure or as marked up for an update with written justification subject to Contractor's safety representative review and approval.

    d. If a safety test has failed initially and re-tested and passed, a justification for the initial failure shall be provided subject to Contractor's safety representative review and approval.

    e. Safety related tests are witnessed and signed off by Contractor's safety representative.

6.3.5 CBTC CONCEPT OF SAFETY DOCUMENT

1. Contractor shall submit a CBTC Concept of Safety Document [CDRL] which shall describe Contractor's application of the System level concepts that ensures CBTC System safety, specifically;

    a. Fail-Safe design (Hardware and Software) approaches used to the implementation of processor-based safety-critical Equipment;

    b. Operational safeguards; and

    c. Methods of ensuring safety-critical data integrity.

2. SFMTA has included a draft CBTC Concept of Safety in the Reference Materials. This draft contains SFMTA-specific safety policies and procedures. Contractor shall base its CBTC Concept of Safety on this draft.

3. The Concept of Safety for processor-based systems shall be in accordance with the IEEE Standard for Verification of Vital Functions in Processor-Based Systems 1483-2000.

6.3.6 INTERIM SAFETY REPORT:

1. Contractor shall submit an Interim Safety Report (ISR) [CDRL] within 1 week of the completion of each Phase installation documenting that:

    a. The Software, Hardware and database deployed has successfully completed factory and PICO validation testing that performed the intended test including:

        i. Open items and Change Requests with safety implications have been reviewed for compliance with safety requirements, analyzed and demonstrated to comply with safety requirements.

        ii. PICO, Software, Hardware and integration tests have been performed.

        iii. All applicable safety certificates have been obtained.

        iv. Database safety verification and validation processes demonstrated showing Open Items and their safety impacts.

    b. Appropriate Temporary Safe Operating Restrictions (TSOR) applicable to the test period are captured and discussed with SFMTA transit operations prior to testing activity including cutover and back procedures and checklists.

    c. Test boundaries are specified, and the safety related signage and procedures are in place in collaboration with SFMTA's operation and maintenance personnel.

    d. If test track is utilized for testing, accompanying safety certificate to validate the use of test track for Train movement with the application conditions to SFMTA.

6.3.7 FINAL SAFETY REPORT:

1. Contractor shall submit a Final Safety Report (FSR) [CDRL] as part of the System Final Design Review package and not less than 40 days prior to commencement of Revenue Service for each Deployment Phase.

2. The FSR included in the System Final Design Review submittal shall summarize safety activities and status of Hazard analysis including the Hazard Log.

3. The FSR shall state that there is no open Hazard that would prevent the Installation, Testing and Commissioning activities to start and that there is no design decision needs to be made after the System Final Design Review that may impact safety.

4. The FSR submitted prior to Revenue Service shall have a summary of the results of the overall analysis, safety verification, validation including the summary of Quality Management Report in accordance with EN 50129:2018, Section 7 or equivalent Standard subject to SFMTA's review and approval.

5. FSRs shall be based on the safety analyses, Hazard Log, and any other relevant output from CBTC Safety Program.

6. FSRs shall capture Software safety activities set out in the SAP including database safety verification and validation activities.

7. FSRs shall document the calculations and methodology demonstrating that the CBTC System satisfies the MTBHE requirements specified in this Section 6.3.

6.4 SYSTEM SECURITY

1. Contractor shall have responsibility for implementing physical and cyber security.

2. Contractor shall demonstrate and adopt a cohesive security design for the CBTC System that minimizes security threats and their impact while facilitating speedy recovery.

3. Contractor shall review System security for the Project with SFMTA to ensure the CBTC Design and implementation is in accordance with SFMTA adopted procedures and protocols.

4. Contractor shall meet with SFMTA to review SFMTA's current procedures and protocols for the ATCS System's security.

5. Contractor shall submit to SFMTA recommendations as necessary to update these procedures and protocols to reflect CBTC System implementation.

6.4.1 SYSTEM SECURITY PROGRAM MANAGEMENT

1. Contractor shall develop a System Security Plan (SSP) [CDRL] to demonstrate how the security program shall be managed during the Contract Term (including both the Procurement Term and Support Term).

2. The SSP shall emphasize the identification threats and vulnerabilities and their control in a systematic manner to achieve the required security.

3. Contractor shall design, test, and start up the CBTC System in accordance with applicable Standards.

4. Contractor shall incorporate the requirements of CSN EN 50159:2010, Railway Applications - Communication, Signaling and Processing Systems - Safety-related communication in transmission systems.

5. Contractor shall comply with Security related Standards and guidelines specified in Section 7 and adhere to the most stringent security protocol and procedures. Train control and communication rooms shall be monitored and protected against unauthorized access.

6. Contractor shall improve or increase System security to maintain parity with its current Base Product line as it evolves, such that SFMTA's System will have the same security features as Contractor provides to new customers at Final Acceptance. Until Final Acceptance, Contractor shall revise its designs to incorporate such improvements with SFMTA approval.

7. The CBTC System shall be designed, manufactured, installed, tested, and Commissioned in a manner that verifies and validates the security of the System.

8. Contractor shall implement a Defense-in-Depth layered approach to information security that uses multiple computer security techniques to help mitigate the risk of one component of the defense being compromised or circumvented (see Section 6.4.3.5 for detail on Identity and Access management).

9. Software provided by Contractor shall apply cybersecurity strategies to protect Software installation from malicious software, security breach, and unintended modification or update of field Software.

10. Communication and control systems shall be secured against unauthorized access and attack, from both the network and test interfaces, and from physical access.

11. Endpoint security of all installed devices shall be provided with incorporation of patch management.

12. Contractor shall design a supported process to manage the release of interim Software security releases, "patches", to ensure the System is secured against future threats.

13. Contractor shall incorporate this process into the SFMTA's Change Control Procedures, defined in Section 15.

14. Contractor shall identify Safety Critical security zones for the CBTC System and apply the necessary levels of protection including cyber-secure interfaces between the CBTC System and external systems such as integrated computer systems and other networked systems.

15. Contractor shall incorporate into the CBTC System a Detection-in-Depth approach to detect actual and attempted unauthorized access to the System, including detection methods for each zone and defensive layer.

16. The Detection-in-Depth approach shall incorporate measures to detect an unusual connection attempt from the System, such as those initiated by Malware.

17. Contractor shall apply attack modeling techniques as specified in Part 3a of the APTA Recommended Practice APTA-SS-CC-03-15, or other approved alternate risk assessment methodology.

18. The Contractor shall at a minimum analyze the Radio Frequency (RF) network, Data Communication System, and any areas identified by the Threat and Vulnerability Analysis.

19. Contractor shall specify the methodology to be used to analyze security risks in the System Security Plan and only use analysis methodology described in the approved System Security Plan.

6.4.1.1 THREAT AND VULNERABILITY ASSESSMENT

1. Contractor shall develop a Threat and Vulnerability Assessment (TVA) [CDRL] to identify CBTC related physical and cybersecurity threats and vulnerabilities, and appropriate mitigation through the design with areas to consider, including but not limited to Contractor:

    a. System vulnerability analysis criteria such as Asset Identification and Analysis, Threat and Vulnerability Identification and Analysis, Scenario Analysis, and Countermeasure Development.

    b. Threat actors against SFMTA, local, and regional government agencies

    c. Countermeasures are identified that they are equal to the threats and vulnerabilities of that particular asset and the potential consequences of an attack.

    d. CBTC System physical vulnerabilities as specified herein.

    e. CBTC System vulnerabilities to access from the outside (wireless data communication, wayside data portals, onboard data portals, OCC portals).

    f. CBTC Software vulnerabilities to Malware and Ransomware.

    g. CBTC System procedural vulnerabilities.

    h. Methods and processes to identify future new vulnerabilities or new and different potential attacks

i. Physical security of train control and communication rooms, cabinets, and other CBTC Equipment enclosures.

2. Refer to SFMTA's Public Transportation Agency Safety Plan (PTASP) for more information on security risk classification acceptance of risk and risk mitigations.

6.4.1.2 THREAT RATING MATRIX

1. Contractor shall use the threat rating matrix specified in SFMTA's SSMP.

2. Contractor may propose a more conservative threat rating matrix, subject to SFMTA's review and approval. Contractor shall include justification with any proposal to use a different threat rating matrix.

6.4.1.3 THREAT AND VULNERABILITY TRACKING

1. Contractor shall develop, manage and maintain a Threat and Vulnerability Tracking List (TVTL) [CDRL] that provides a process and reporting method that verifies the threat and vulnerability mitigating measures identified in the TVA required by the Contract have been completed or are in place.

2. Contractor shall deliver the TVTL as a live database where Threat and Vulnerability, their risk level and mitigations are tracked and managed.

3. The TVTL shall be operational through the entire Contract Term (including both the Procurement Term and the Support Term).

4. All identified Threats and Vulnerabilities shall be recorded in the TVTL.

5. Contractor shall specifically identify the proposed mitigating measure by Drawing number, procedure number, analyses and maintenance action for each Threat.

6.4.2 PHYSICAL SECURITY

1. Contractor shall design and provide the CBTC System assets such that they allow physical access to elements of control system such as modems, terminals, workstations, equipment rooms, and onboard controllers only to authorized persons.

2. Access limitation shall also detect unwanted or unauthorized persons seeking to gain access to the CBTC System, including its Software, subsystems and physical components.

3. Contractor shall design and provide a CBTC System that minimizes the impact of a threat through redundancy and dispersion of CBTC assets.

4. Contractor shall demonstrate that a single attack would not cause total System failure or cause major impact to the operation.

5. Contractor shall design and provide a CBTC network architecture, equipment and cabling such that it minimizes the safety and operational impact of arson and fire related Hazards.

6. Some elements such as Local Control Panels or platform depart buttons used for Automatic Turnback, or onboard Equipment in the passenger compartment of vehicles, will be installed in publicly accessible areas. Contractor shall ensure these devices are physically secure from tampering, vandalism, or forced entry, and that only authorized users may physically access them.

6.4.3 CYBER SECURITY

6.4.3.1 GENERAL

1. This Section provides the framework for information security activities for electronic elements of the Project, interfaces between elements in the Project, and interfaces with elements of related Projects, and interfaces with SFMTA Operating System.

2. All Project cybersecurity work shall be completed in collaboration with SFMTA and in accordance with the SFMTA Requirements for Technology Projects included in Appendix J to the Agreement and other SFMTA cybersecurity policies and procedures.

6.4.3.1.1 COMPLIANCE STATEMENT

1. Contractor shall submit a Cybersecurity Compliance Statement [CDRL] specified in the SSP for the Project certifying compliance to SFMTA's most current standard for information security.

2. Each Subcontractor of Contractor's involved in achieving the requirements of this Section shall submit a compliance statement. Each statement shall be signed by an appropriate representative of that company.

6.4.3.2 PROPOSED AND DRAFT CONFIGURATION

1. Contractor shall submit a proposed Cybersecurity Documentation Manual [CDRL] for SFMTA review prior to initiating information security related actions and activities.

2. The Cybersecurity Documentation Manual shall, at a minimum, demonstrate compliance with the applicable Contract Specifications.

3. The Cybersecurity Documentation Manual shall:

    a. Describe how all devices conform to SFMTA adopted security and cybersecurity protocols specified in this Section 6.4.3.

    b. Include a Requirements Traceability Matrix (RTM) for all security requirements, including Contractor derived requirements, that shows how security requirements are developed and confirmed throughout the Project.

    c. Describe how Contractor will ensure the accuracy and consistency of electronic data.

    d. Contain the required documentation specified in this Section and formatted to ensure that all cyber security requirements have been captured by Contractor

    e. Specify the specific mitigations that have been implemented to assure a secure System environment (all components).

    f. Specify Project Migration requirements to maintain a secure System environment, including all components, as the Project Phases are implemented.

4. Following incorporation of all agreed review meeting comments and SFMTA directed revisions, the proposed manual will be approved as the Draft Cyber Security Manual for use during initial and final integration activities.

5. The CBTC System Equipment shall be configured to meet the adopted security and cybersecurity protocols detailed in this Cybersecurity Documentation Manual. The final Cybersecurity Documentation Manual is to be updated to an as-built status and submitted at the completion of final integrated testing.

6. SFMTA, at its discretion, may perform penetration testing on the CBTC System environment. Contractor shall submit and perform response and corrective actions based on outcomes of this testing.

6.4.3.2.1 SPECIAL SUBMITTAL OF PRE-FINAL CONFIGURATION

1. Contractor shall develop and provide a listing of all Configurable elements of the Project.

2. These elements shall include:

    a. Elements that are Configurable by SFMTA without Contractor intervention

    b. Elements that are Configurable by the CBTC System requiring Contractor intervention

3. Contractor shall arrange the contents of the manual according to the CBTC System Architecture and show the relationship of Configurable items to corresponding Software and Hardware supporting the Configurable item's function.

4. Contractor shall submit a Draft Configuration Manual [CDRL] following completion of any integration activities to show those specific Configurations and their relationship to the rest of the CBTC System related to the environment or System implemented.

5. Contractor shall make changes and submit the Draft Configuration Manual as the Pre-Final Configuration Documentation Manual [CDRL] for detailed and final review by SFMTA Information Security personnel.

6. This Pre-Final Configuration Documentation Manual shall be revised per direction and comments received from meetings and formal reviewer mark-ups.

7. Contractor shall make changes and resubmit said manual, as required by SFMTA, until accepted by SFMTA as Final. Acceptance of the Final Configuration Manual [CDRL] submittal is required as a condition of Final Acceptance.

8. The Final Configuration Manual shall describe in detail the Configuration of all Project or CBTC System Configurable items.

9. While the Contractor is responsible for developing the complete listing of SFMTA Configurable values as identified in 6.4.3.2.1 1 a., at a minimum the system shall include all required user-Configurable values in the specification, including the following SFMTA Configurable capabilities:

    a. Schedule

    b. Service Line Assignments, including alphanumeric indicators, and capability to add additional lines

    c. Dwell Time, per stop, per platform, and per schedule:

        i. minimum Dwell

ii. nominal Dwell

iii. maximum Dwell

iv. timed hold

d. Platform hold-times

e. Service patterns

f. Automatic Train Regulation Parameters

i. Headway Mode

ii. Schedule Mode

iii. Anti-bunching thresholds

iv. Earliest control time settings

v. Travel time between station - train's recommended pacing speed between stations

vi. Maximum train delay

vii. Maximum headway deviation

g. Berthing parameters, including multiple pre-defined locations per platform/stop, and configuration to disable certain doors due to platform length based on Berthing location and Consist length

h. Target braking rate

i. TSR Zone, including TSR tracks, length, and speed.

j. Energy Savings mode

k. Early Control Time delay

l. Energy Savings parameters, including magnitude of changes to the impacted operation and performance parameters based on configurable schedule/timetable inputs

m. Local control console activation time

n. Blue Light System speed limit

o. Service Line and Train Tracking GUI/display parameters

p. Fault Alarm and indication behavior for Train Operator, Train Maintainer, and Transportation Controller, including ATS User configuration of thresholds for train-delay, out-of-headways, and other alarm thresholds, and SFMTA configuration of alarm optics, duration and reaction, alarm category, and alarm type.

q. Distance for TOD visual and audible warning for end of ATO territory.

r. Operator Simulator scenarios

6.4.3.3 CYBERSECURITY REQUIREMENTS

1. Contractor shall submit designs, Software, Hardware and System integration for all CBTC System functions, CBTC subsystem functions, and CBTC Equipment, that meet the minimum Cybersecurity Standards listed in Section 7.

2. Contractor shall maintain awareness for opportunities to improve or increase CBTC System cybersecurity methods as industry advancements evolve. Contractor shall submit designs that incorporate such improvements with SFMTA approval.

3. Contractor shall, in collaboration and agreement with SFMTA, specify the network architecture, the use of SFMTA network tools, the provision of CBTC Network tools, and the interconnection between the CBTC System and SFMTA existing framework.

4. Contractor shall develop, detail and submit the cybersecurity policies used to protect the CBTC System.

6.4.3.4 NETWORK SEGMENTATION/ISOLATION

1. Contractor shall use firewalls to segregate/isolate the CBTC System from SFMTA existing technology systems.

2. Contractor shall, in collaboration and agreement with SFMTA, provide Network Intrusion Detection System (IDS)/Intrusion Prevention System (IPS) solutions and any additional SIEM tools that monitor and measure the environment to be used for both the CBTC Network and incorporated in SFMTA existing network.

3. SFMTA uses its own SIEM tools. Contractor shall either use SFMTA's tools or integrate Contractor's tools and systems into SFMTA existing tools, as necessary.

4. Contractor shall automatically alert SFMTA of all network intrusions detected and/or prevented by the IDS/ IPS solution including any additional SIEM tools provided that monitor/measure the CBTC System environment.

6.4.3.5 IDENTITY AND ACCESS MANAGEMENT

1. Contractor shall incorporate an Active Directory to enable administrative network access management.

2. Contractor shall submit a list of entry points required by the CBTC System design for SFMTA approval.

3. Contractor shall develop details by functional role the purpose for each access and the privileges permitted by the access. SFMTA will determine the acceptability of the number of entry points required by the CBTC System design.

4. Contractor shall design layering of security and access management using Defense in Depth methodology and the FTA Transit Security Design Considerations referenced in Section 7 (Codes and Standards) in collaboration with SFMTA TSI staff.

5. Contractor shall use protective measures addressing all threats phases – deterrence, detection, defense, mitigation, response, and recovery as part of their TVA.

6. Contractor shall incorporate into the design a security framework requiring all users, whether in or outside the organization's network, to be authenticated, authorized, and continuously validated for security Configuration and posture before being granted or keeping access to applications, data and management services.

7. The System shall use role-based access to all systems and subsystems.

8. Contractor shall update all passwords to comply with SFMTA security Standards referenced in Section 7 (Codes and Standards).

9. Passwords should be at least 8 characters in length, comprising of at least 3 of the following:

    a. Uppercase

    b. Lowercase

    c. Numeric

    d. Symbols

20. Passwords shall be communicated securely to appropriate Agency personnel.

21. Each Train Operator shall have a distinct password (no shared passwords) based on a separate ID.

22. All user account access shall use Multiple Factor Authentication (MFA).

23. Each CBTC user account shall have the capability of being disabled (locked) in response to multiple failed access attempts or Contractor may propose an alternative solution subject to SFMTA's approval. Refer to SSMP for more details and existing failed login/password management and examples of alternative solutions.

24. No Equipment or System shall be installed or connected to SFMTA's network with its default password still enabled.

6.4.3.6 NETWORK SWITCHES AND ROUTING EQUIPMENT

1. CBTC network switches and routing equipment shall, at a minimum, meet the following requirements:

    a. Support logical disabling of all unused ports on network switches and routers, including the USB ports.

    b. Appropriately label cabling connected to network switches and routers. Labels should identify VLAN (if applicable) and/or network function (such as Temporal Convolution Network (TCN), (Employee First Network) EFN, Closed-Circuit Television (CCTV), Ticket Vending Machine (TVM)).

    c. Ensure front and rear ports are accessible.

    d. Ensure each switch and router firmware version is the latest current released version from the manufacturer.

    e. Apply all security patches from the manufacturer for CBTC switches and routers.

f. Configure network device to maintain security event data for 90 days locally and configure log to overwrite event data after 90 days.

g. Configure network device to transmit security event data to Agency Security Information and Event Management (SIEM) and SFMTA network operations staff.

h. Disable or remove inactive and unused accounts and login access credentials.

i. Provide documentation identifying which Agency networks are configured on the switches present at the facility. Include a network diagram for the facility.

j. Provide details and documentation for the installation and removal of Contractor-installed/requested ETHERNET networks or networked devices used during the construction process prior to installing such equipment. At removal, provide details documenting disablement and removal including specific port Configurations.

k. Provide details and documentation for the installation and removal of temporary installed or requested Wi-Fi networks used during the construction process prior to installing such equipment. Include Service Set Identifier (SSID) used and security protocols used. At removal, provide details documenting disablement and removal.

6.4.3.7 SERVERS

1. Contractor shall ensure server security prior to System Acceptance.

2. Contractor shall provide the following to SFMTA as a condition of Final Acceptance:

   a. Details of all Windows and Linux servers at the facility and their anti-Malware requirements and Configurations. Contractor shall supply anti-Malware tools consistent with existing SFMTA tools.

   b. Identify all server products in use, version number, and server product update frequency.

   c. Specify the frequency and method used for updating installed anti-Malware Software including regularly released signatures in addition to product Software releases.

   d. Confirm all files are scanned for Malware on ‘write’ to the file system.

   e. Confirm real-time scanning for Malware is provided on all Contractor installed systems vulnerable to Malware.

   f. Described enabled Malware protections. Contractor shall enable Malware protections with agreement from SFMTA.

   g. Confirm full System scans for Malware are configured to run at least every 24 hours.

   h. Provide details of the operating systems in use on all servers at the facility including details on their installation and Configuration.

   i. Confirm all default operating System passwords have been changed from their default and detail where current passwords have been stored and to whom the current passwords were communicated.

j. For new servers added to SFMTA infrastructure, Contractor shall submit the following information:

i. Demonstrated compliance with the Agency Window and Linux server Standards where applicable,

ii. Documentation for any server removed from the System as part of the hardening process,

iii. Dates and versions of the latest security patches applied. Note any outstanding security patches and the dates for installation. Document which systems have not be patched and the reason for not patching them,

iv. Detail the port number and service for the Transmission Control Protocol (TCP)/User Datagram Protocol (UDP) service in use on each server,

v. Confirm all web-based interfaces are only enabled where necessary and are encrypted using the latest version of Hypertext Transfer Protocol Secure (HTTPS).

vi. Confirm all default sample scripts and non-required Software have been removed.

vii. Confirm all diagnostic Software used during installation has been removed unless otherwise authorized by SFMTA.

viii. List all user and service accounts that were installed. Detail the type of account privileges that were enabled for each account (e.g., administrator, read-only) and Role Based Access Control (RBAC) implementation, where required.

6.4.3.8 OPERATING SYSTEMS

1. Operating Systems (OS) must be supported by the OS vendor and not be on a version due to expire within 2 years of Final Acceptance.

2. Contractor shall support the OS via support agreement made with the OS vendor, if necessary.

3. Following Final Acceptance, Contractor shall update the OS as required by the Obsolescence Management Plan as part of the Support Services.

6.4.3.9 APPLICATIONS

1. Contractor shall submit a List of Applications installed at each facility [CDRL].

2. The list of applications installed at each facility shall, at a minimum, include the following:

a. Version numbers.

b. Security patch identification number and date of patch.

c. Known vulnerabilities, if any, for each application that cannot be patched.

d. Additional hardening activities implemented for each application in accordance with SFMTA security Standards.

e. Confirmation of the updating and/or deleting of default usernames and passwords on the applications installed and updated and meet Agency Standards.

f. Document to whom updated usernames and passwords were communicated and the method used.

g. Custom code, if used, demonstrating compliance with SFMTA Secure Code Standard.

6.4.3.10 MONITORING

1. Contractor shall monitor all CBTC System functions, components and data flows.

2. Contractor shall coordinate with SFMTA TSI on visibility of alerts.

3. Contractor shall identify which systems and subsystems send heartbeats (periodic signal to indicate normal operation) to the Network Management System (NMS) or other monitoring equipment and the type of heartbeat sent (e.g., TCP/UDP/ ICMP).

4. Contractor shall develop, with input from SFMTA TSI, a list and description of alerts to share outside of the CBTC System and what appropriate actions to document.

6.4.3.11 ENCRYPTION

1. All data shall be encrypted unless specifically authorized by SFMTA:

   a. For transmission data, Contractor shall configure all TLS connections for TLS 1.2 and higher. Note any version lower than Transport Layer Security (TLS) Level 1.2 at each facility.

   b. For data at rest, Contractor shall employ encryption using Advanced Encryption Standard (AES) or equivalent subject to SFMTA review and approval.

   c. Contractor shall provide SFMTA with a process to ensure protocols are updated as new versions of Software are published.

6.4.3.12 NETWORK DISCOVERY SCAN

1. Contractor shall complete network discovery scans at each CBTC local and remote network facility to ensure that only authorized devices are present on the network.

2. Contractor shall provide SFMTA with a report covering the details and actions and the outcome of any network discovery scans it performs.

3. Contractor shall obtain SFMTA approval prior to conducting the scan in accordance with the Technology Change Advisory Board Process described in Section 15.3. Contractor shall include in its schedules and plans any lead time necessary to complete this process.

4. Contractor shall recommend to SFMTA the optimum frequency of network discovery scans based on its experience with other CBTC systems.

5. Contractor and SFMTA shall confer and agree on the frequency of performing network discovery scans.

6.4.3.13 DOMAIN NAME SYSTEM

1. Contractor shall specify which DNS servers are being used to support information technology resources at each CBTC network facility. Coordinate with SFMTA as required to perform the Configuration.

6.4.3.14 SECURITY DATA LOGGING

1. Contractor shall:

    a. Coordinate with SFMTA to identify which CBTC subsystems should be configured to send security event log data to SFMTA SIEM.

    b. Design shall indicate which systems are to be so configured and final Configurations will be documented in the as-built Drawings.

    c. Configure all logs to overwrite themselves when the 90-day period is reached, or the period configured per other requirements (if any).

    d. Detail how audit logs are protected from unauthorized access.

    e. Provide a listing of all loggable data, diagnostic information or specific events for SFMTA to review and distribute logs.

6.4.3.15 WIRELESS NETWORKS

1. At each facility, Contractor shall assemble Wireless Network Documentation [CDRL] in coordination and collaboration with SFMTA, for the following:

    a. List all wireless networks available, including SSIDs and the location of access points.

    b. Scan for rogue wireless networks and identify unauthorized SSIDs. Contractor shall request permission from SFMTA to perform a network scan and may only perform scans after receiving authorization from SFMTA. Document date and actions taken.

    c. Disable and remove unauthorized Wi-Fi access points; document actions taken.

    d. Confirm 802.1x has been enabled to support device identification when attaching to the Local Area Network (LAN).

    e. Bluetooth devices: Scan for Bluetooth devices, document devices discovered, and describe actions taken to disable Bluetooth devices and harden against future access.

    f. Contractor shall follow the Technology Change Advisory Board Process in the performance of this Work.

6.4.3.16 DUMB END DEVICES (DED)

1. Contractor shall supply Dumb End Devices (DED), pieces of Hardware, sensors, or other appliances, to transmit necessary information of SFMTA operational environment to the CBTC System.

2. Contractor shall submit details of DEDs at each facility [CDRL].

3. The DEDs shall, as a minimum, include the following types of Hardware:

    a. Emergency Telephone Devices, Customer Emergency Station (CES), Passenger Emergency Telephone (PET), Emergency Telephone (ETEL)

    b. Track Intrusion Detection System (TIDS), CCTV Cameras, Detection System (in the TCN)

    c. VOIP (Voice Over Internet Protocol), PBX (Private Branch Exchange) Telephone

d. Access Control, Card Reader and Door Controller

e. Power Monitoring, Power Meters

4. For every DED, Contractor shall:

a. Provide a listing of all products containing firmware including the product version and firmware version.

b. Update all DED's firmware to the required firmware version with releases from the manufacturer such that the entire equipment supply has backward or forward compatibility relative to any DED firmware release consistent with Contractor's Obsolescence Management Plan.

c. Update DED's default password and remove unnecessary accounts where applicable.

d. Apply all security patches to DEDs documenting the date security patch was installed and the patch level.

e. DED management shall be via HTTPS and/or SSC. Confirm HTTPS, File Transfer Protocol (FTP), Telnet, and/or other insecure interfaces and protocols have been disabled for each DED.

f. Document which DEDs support Role Based Access Control (RBAC) and level of privileges for normal operating accounts.

g. Describe security Configuration settings on DEDs to ensure access is restricted to only authorized devices, networks, or individuals.

h. Attach a list of assets per SFMTA's asset data collection process, including how devices are supported by Contractor and the type of remote access (e.g., Remote Data Service [RDS], VPN, black box).

i. Describe physical and cyber security features protecting the device from unauthorized access.

j. Remove and/or disable all Software components that are not required for the DEDs to function.

k. Secure and harden any DED using Wi-Fi for communication and document actions taken.

l. Confirm all DEDs work as intended following all security hardening tasks.

m. Contractor shall follow the Technology Change Advisory Board Process in the performance of this work.

6.4.3.17 PROGRAMMABLE LOGIC CONTROLLERS (PLC) AND INTELLIGENT ELECTRONIC DEVICES (IED)

1. Contractor shall submit design and operational information for Programmable Logic Controllers (PLCs) and Intelligent Electronic Devices (IEDs) at each facility [CDRL] to establish the following:

a. PLCs and IEDs are protected from unauthorized access and modification in accordance with the References and Agency Security Standards.

b. Default usernames and passwords have been updated and new passwords are aligned to Agency Standards and have been securely communicated to appropriate SFMTA information security personnel.

c. Communication protection from PLC to output device ensures data integrity.

d. PLC features protect the device from physical and cyber-attacks.

e. Confirm the version number of the PLC and IED and ensure firmware is in 2 revisions of the latest manufacturer provided release. Include any security impacting issues that have been identified with the PLC or IED.

f. Verify security hardening action taken for each PLC and IED resulted in no negative performance impacts.

6.4.3.18 OTHER DEVICES

1. Contractor shall submit documentation showing compliance to information security and cyber security requirements for all other Equipment (including Uninterruptible Power Supply [UPS], Global Positioning System [GPS] clocks, radio Bi-Directional Amplifier [BDAs])

2. Documentation shall include the following:

a. Contractor shall demonstrate coordination with Suppliers, Subcontractors, integrators, and providers of Equipment Suppliers and vendors to ensure that no obsolete or unsupportable Equipment is delivered to SFMTA at Final Acceptance.

b. All Equipment, components, embedded Hardware, firmware, operating systems, and Software shall be certified by Contractor through signed statements attesting to other devices as current and supportable for two (2) years following Final Acceptance. Contractor shall include these details within Contractor's Obsolescence Management Plan.

c. Contractor shall work in coordination and collaboration with SFMTA TSI to review and confirm compliance to these requirements and follow the Technology Change Advisory Board Process in the performance of the work.

6.4.3.19 SECURE CODING

1. Contractor shall submit Secure Coding documentation [CDRL] for the following:

a. Outputs from Contractor Software development tools from Source Code Security Analyzers | NIST (based on the source code language).

b. Any custom written code or code that has been altered to function in SFMTA environment including the location of the code, code language and version, and any tools, libraries or frameworks required to support the code.

c. Actions Contractor has taken to ensure custom written Software code was developed, maintained and controlled in a secure environment and the accuracy and contains only Contractor required content.

d. Supply-chain information demonstrating the integrity of custom written code during transition.

e. Details of any security code scanning tools that were used to validate the integrity of the custom written code. Include a high-level statement summarizing the findings of the scanning.

f. Demonstrate that all custom-written code complies with the following Open-Source Web Application Security Project (OWASP) references:

i. Interjection Attacks

ii. Broken Authentication

iii. Sensitive Data Exposure

iv. XML External Entry Injection (XXE) Attacks

v. Broken Access Control

vi. Security Misconfiguration

vii. Cross Site Scripting (XSS)

viii. Insecure Deserialization

ix. Vulnerable Components

6.4.3.20 VEHICLE ON BOARD EQUIPMENT

1. All enclosures for Vehicle onboard Equipment shall be secured with a tamper proof locking device to prevent unauthorized physical access to Software residing in the Equipment.

6.4.3.21 FACILITY ACCESS

1. Contractors working on the Procurement Term who have physical access to SFMTA facilities shall close their access prior to Final Acceptance.

2. At Final Acceptance, Contractor shall provide a report describing each of its employees (including employees of Subcontractors and Affiliates) who have SFMTA facility remote access.

3. The access report shall detail how access was provided and the expected access termination date.

6.5 NETWORK SECURITY SYSTEM (NSS)

6.5.1 NSS: DESCRIPTION OF WORK

1. The work of this Section includes, but is not limited to, providing all engineering, labor, Materials, tools, Equipment, and incidentals necessary for the final design, supply, test, and Commissioning of a Network Security System (NSS), for the CBTC System, in accordance with the Contract requirements, including documentation of as-built conditions, acceptance tests, operational tests and training.

2. Contractor shall provide any licenses necessary to deliver the scope of work described in this Section, except as provided under Section 9 (SFMTA Furnished Items).

a. Contractor's vendors may require certain licenses to be purchased in SFMTA's name as the end-user. SFMTA agrees to cooperate with this effort, but the Contractor shall pay all invoices from its vendors. If the vendor requires payment from the SFMTA directly, the Contractor agrees to a price reduction equal to the amount invoiced to SFMTA by its vendor.

6.5.2 NSS: SUBMITTALS

1. Contractor shall submit, at a minimum:

    a. An NSS Overview [CDRL], including a detailed description of how the NSS provides "Defense in Depth" security, a detailed description of use cases the NSS provides protection from, and a comprehensive description of the protection provided against specific threats as specified by Contractor in its use cases.

    b. The NSS Overview shall include overall NSS architectural schematic(s) and/or block diagrams detailing all devices and network interfaces to SFMTA systems.

    c. The NSS Overview shall also include a text description of how Contractor proposes NSS meets all recommended best security practices of the network Standards listed in Section 7 (Codes and Standards).

    d. Detailed data sheets and support literature of each NSS System element or device supplied, to including functional and operating descriptions, typical applications and recommend practices [CDRL].

6.5.3 NSS: FUNCTIONAL REQUIREMENTS

1. A separate and independent NSS shall be installed at each Control Center:

    a. CBTC System and sub-systems supplied by Contractor ("CBTC In Band NSS").

    b. SFMTA supplied Data Cable Network (DCN) systems, ("CBTC DCN NSS"), that are utilized by Contractor.

2. Each NSS shall consist of a combination of dedicated Hardware devices and associated Software that shall have multiple layers of security to the CBTC System and DCN.

3. Contractor shall dedicate these NSSs solely to the CBTC and DCN and they shall not be associated with or linked to any other network or System at SFMTA, except as specifically authorized by SFMTA or provided in these Specifications.

4. Contractor shall design and provide the CBTC System as SFMTA mission critical and must provide Availability on 24 hours per Day and 7 Days per week.

5. Contractor shall collaborate with SFMTA TSI to determine the setup and processes to be used implementing each NSS. This collaboration shall include:

    a. NSS design and Configuration to support SFMTA TSI reporting requirements and security control processes.

    b. Technical documentation and training to designated SFMTA TSI personnel to provide an understanding of the NSS functionality detail and to interpret and respond to NSS alerts.

    c. 24 hours per Day and 7 Days per week SFMTA TSI access to the NSS monitoring and alerting systems.

    d. Event alerts Configuration and monitoring actions that are distributed directly to SFMTA staff or distributed via integration into existing SFMTA current monitoring and alerting tools.

6. The CBTC System and its network shall be independent of all other SFMTA networks and systems, and shall be closed, with access limited to designated internal SFMTA staff or authorized SFMTA contractors, as provided in the approved System Final Design.

7. The NSS shall protect the CBTC and DCN from both internal and external threats, whether intentional or unintentional.

8. Contractor shall configure all Hardware, Firmware, and Software elements of the NSS and shall fully configure all devices in the CBTC DCN as part of the NSS.

9. All existing SFMTA devices and any SFMTA supplied DCN components, as detailed in the Contract Documents, shall be incorporated into the NSS, except as directed by SFMTA Project Manager.

10. Contractor shall, as required, update all communications devices to comply with NSS requirements without compromising resiliency or Availability of CBTC operations.

11. Contractor shall work in coordination and collaboration with SFMTA TSI to review and confirm compliance to the requirements in this Section 6.5.3 and follow the Technology Change Advisory Board Process in the performance of the work.

12. Contractor shall develop and supply the NSS using only technology that is commercially available.

13. The NSS shall not include any proprietary security countermeasures that have not been identified in NIST 800 or the Codes and Standards in Section 7.

14. Each NSS shall be independent from any other NSS device and equipped within a workstation.

15. Each NSS shall function independently of the operation of any other NSS.

16. Contractor shall supply all engineering, labor, tools, and Materials required to Furnish completely tested and a fully operational NSS in accordance with Contract requirements, including documentation of as-built conditions and acceptance test procedures and operational tests procedures.

17. Contractor shall develop, submit and manage the processes and designs to support integration and interoperability with Third-Party Systems and other SFMTA systems in order to meet the requirements included in this Contract Specification and the SRD as provided in Section 4.3.3. Contractor shall develop these designs collaboratively with SFMTA and obtain SFMTA approval for these designs before proceeding to implementation. Contractor shall make changes to its designs as needed in response to SFMTA comments received during the Design Review process.

6.5.4 NSS: THREATS

1. Threats are any man made or natural element that can act in either an accidental or intentional manner to adversely impact the function, performance, and operation of the CBTC System. Threats can manifest by connection of any Hardware devices, Software code, viruses, Malware, or any other function that can result in impacts to the safety, security or Reliability of the CBTC System, SFMTA operations or SFMTA stakeholders. Threats may be introduced, by either internal SFMTA or external parties, at any point in the communication or data networks.

2. The NSS shall secure all network elements, Hardware, subsystems, Software, and data transport in the CBTC System and DCN systems that are part of Contractor's design, to include, at a minimum:

    a. Office systems and all interconnecting networks and devices, in both the primary and backup offices and at any remote NSS or CBTC workstation.

b. CBTC System interfaces to any external SFMTA systems or entities including but not limited to any Contractor or Vendor Access via dial-in or VPN access, including all associated firewalls.

c. CBTC System interfaces to Internet access and associated firewalls (Internet access shall only be permitted as approved by SFMTA).

d. CBTC Interfaces to any wired carrier supplied networks.

e. CBTC Interfaces to any wireless carrier supplied networks.

f. Contractor provided Network Management System (NMS).

g. Contractor provided Data Cable Network (DCN) network elements, including fiber optic, copper or other interfaces utilized for data message transport.

h. All CBTC wireless systems.

6.5.5 NSS: STANDARDS

1. The NSS shall be designed by Contractor consistent with the latest Standards and recommended practices in IETF, IEEE and ITU/T, ITU/R, TIA/EIA, NIST SP800-82, NIST SP800-53 Rev3, ANSI/ISA-99.00.01-2007, ANSI/ISA- 99.02.01-2009, DHS CSSP, APTA, FRA and NERC CIP recommended practices for telecommunications network security, tailored as necessary to be compatible with existing SFMTA TSI reporting requirements and security control processes.

2. Final design and Configuration of the NSS shall be coordinated with and approved by SFMTA TSI.

6.5.6 NETWORK ELEMENT COMPATIBILITY

1. The NSS shall be designed to ensure compatibility with all Hardware and Software (including operating systems) supplied by Contractor, as approved by SFMTA TSI.

2. The NSS shall be equipped to communicate directly with each network element to be protected by the NSS without the need for any intermediate protocol conversion or separate interface devices, except as approved by SFMTA

3. The NSS shall be fully compatible with existing and new Network Switches and Serial Servers.

4. Network Switches and Serial Servers shall be configured to be monitored and controlled by the NSS without impacting operations or Availability of the CBTC System.

6.5.7 NSS ARCHITECTURE

1. The NSS architecture shall be based on the principle of ‘Defense in Depth’.

2. The NSS shall be a hierarchical implementation that works in conjunction with the various network elements of the System to achieve the desired levels of protection of the networks and systems.

3. The NSS shall consist of a platform of Hardware and Software dedicated to the NSS exclusively.

4. A failure of any portion of the NSS shall not impede normal functionality of the CBTC System.

6.5.7.1 INTEGRATED SECURITY EVENT MANAGEMENT / THREAT MANAGEMENT

1. Contractor shall provide a NSS design, for SFMTA review and approval, that utilizes devices that combine NSS functionality of security event management, and threat management into a comprehensive system.

2. The NSS design shall include the use of devices to provide firewall, Intrusion Detection System (IDS), Intrusion Protection System (IPS) and alarm reporting functionality as described in this Section 6.5.

3. The use of firewalls, IDS and IPS shall not relieve Contractor from the requirements for minimizing latency, preventing single-point-failure or other functionality described herein.

6.5.7.2 CENTRALIZED MANAGEMENT

1. Contractor shall provide functionality for the NSS to be managed from a single central management terminal that shall consolidate all NSS management, control, Configuration and reporting functions.

2. In the event that NSS devices are used with dissimilar reporting and management Standards and/or formats, separate management systems may be proposed, however all similar sub-elements (i.e., Ethernet switches or Firewalls) shall be managed and configured from a single central management system supplied by the manufacturer of that element.

3. The central management system and all NSS workstations proposed shall be installed at the same locations as the Network Management Systems (NMS).

4. The design of the NSS central management shall be submitted as part of the Preliminary and Final Design review packages.

5. The central management terminal shall have secure remote accessibility. The design for this secure remote access shall be done in coordination with SFMTA TSI.

6.5.7.3 MESSAGE LATENCY AND INTEGRITY

1. The NSS shall function without adding any data message latency.

2. The NSS shall function in a manner that any security countermeasure shall not introduce any modifications to CBTC data traffic.

3. Contractor shall not request an exception to the prohibition of added message latency or data modification.

4. Contractor shall submit justification for the proposed minimum acceptable latency periods in expected data structures, consistent with Contractor's overall System design.

6.5.7.4 SINGLE POINT OF FAILURE AND FAILURE MODES

1. Contractor shall design and provide the NSS without any single point of failure within the System that causes the entire NSS System to stop working at any point in the System.

2. For example, if a device, such as a firewall protecting the network from external port "A" fails, it shall not impede traffic from external port "B".

3. The device shall include redundant, hot-switched power supplies and redundant components that shall not impede data message exchange upon an NSS element failure.

4. Under no circumstances shall the device responsible for securing a network perimeter fail in an open state when becoming nonoperational, thereby exposing the network to unprotected access from exterior sources.

6.5.7.5 BACKUP NSS

1. Contractor shall supply two identical NSS systems for the primary and the backup Control Centers.

2. In the event of a failure or evacuation of the primary Control Center systems, the NSS System shall switchover to the backup Control Center with the same sequencing as the CBTC System.

6.5.8 NSS: LAYERS OF SECURITY AND FUNCTIONALITY

1. Contractor shall design and supply NSS functionality that includes:

    a. Port Access and Lock Down and Disable.

    b. Firewalls

    c. RADIUS Server (or approved alternative)

    d. CBTC System Intrusion Detection System (IDS)

    e. CBTC System Intrusion Prevention System (IPS)

    f. Antivirus and anti-Malware

    g. Remote Access

    h. Virtual Private Network (VPN)

    i. Security Information and Event Management (SIEM) including alerts lists and monitoring activities.

    j. Compliance Management and Reporting

    k. Software Configuration Management and Reporting

2. Contractor shall collaborate with SFMTA to develop processes to integrate SFMTA tools i.e. SIEM information, to the above functionality.

3. Contractor shall submit detail design documentation for each NSS Functionality Design [CDRL]including required Software, Hardware and integration.

6.5.8.1 PORT AND ACCESS, LOCK DOWN AND DISABLE

1. All switches, routers, firewalls, servers and other device with I/O ports or external connections of any kind including but not limited to Ethernet, serial, USB, Firewire, CD/DVD, Wi-Fi, Bluetooth, floppy disk or other that may serve as an entry point for a threat, shall have any open, unused I/O port or connection locked down and disabled.

2. Enabling and use of any disabled port shall be under the direct control of Authentication, Authorization, Accounting (AAA) functionality using RADIUS or TACACS+ protocol. Contractor shall describe the use of these protocols and where they are applicable to SFMTA.

3. Contractor shall supply the NSS in compliance with IEEE 802.1x and Codes and Standards specified in Section 7.

6.5.8.2 INTRUSION DETECTION SYSTEM (IDS) AND INTRUSION PREVENTION SYSTEM (IPS)

1. Contractor shall work with SFMTA's existing IDS and IPS to provide intrusion detection and take preventive measures without direct human intervention.

2. Contractor shall submit detail design documentation describing the details and Configuration of the IDS and IPS[CBTC].

3. The integrated IDS & IPS shall perform seamlessly in conjunction with the firewalls and other Contractor supplied NSS devices to automatically prevent malicious packets or data from propagating into SFMTA network and systems,

    a. The integrated IDS & IPS shall alert, log and report all such instances.

4. The integrated IDS & IPS shall not introduce any modifications or latency to CBTC data traffic flows or processes.

5. The IDS and IPS shall include a subscription for harmful traffic patterns and a database of viruses, worms, trojans, Malware and any other harmful code or attacks.

6. Contractor shall update the IDS and IPS database automatically over the Internet by the manufacturer each month. Contractor may update the IDS and IPS database more frequently as approved by SFMTA.

7. The IDS and IPS in the NSS shall be updated automatically without human interaction and in a manner that does not expose the NSS IDS and IPS directly to the Internet unprotected. Contractor shall submit an alert to SFMTA whenever these updates occur.

6.5.8.3 FIREWALLS

1. Contractor shall supply separate, independent device-level firewalls at each and every point of entry from connection points to the CBTC Systems, and include, but not be limited to, all wired, wireless, dedicated fiber connectivity or any other form of connection that constitutes a route into, or from, a system external to SFMTA systems. For reference, SFMTA currently utilizes Palo Alto Firewalls in its current environment.

2. Firewalls shall also be installed between the Control Centers (primary and backup) and the CBTC and DCN system devices, to prevent harmful accidental or intentional malicious access to the offices from a field site.

3. No single point of failure in any component of the device, including power supplies, shall permit the failure of more than one protected external connection or to allow a device to fail open and exposing SFMTA to external threats.

6.5.8.4 AAA SERVERS AND FUNCTIONALITY

1. Contractor shall supply AAA (Authentication, Authorization and Accounting) servers at the primary and backup Control Centers to manage network access and message exchange in the two-step AAA transaction process with the user (user or network element).

2. Contractor shall submit the design and details of the AAA transaction process for approval.

3. The database of user profiles (including, but not limited to, usernames, passwords, MAC addresses) as well as the accounting shall be maintained in SQL.

4. AAA Accounting shall be utilized for management and forensic purposes for audit purposes and to provide a permanent record for the investigation of a security related event. No billing functionality is required.

5. AAA management of the edge devices (including switches, routers) shall comply with IEEE 802.1x and Codes and Standards specified in Section 7.

6. AAA servers shall be fully compatible with all new and existing devices

7. AAA servers shall be updated to accommodate AAA without any impact to Control Systems operations and Availability requirements.

8. Contractor shall submit details for specific AAA Functionality [CDRL] including designs and processes to support resiliency and redundancy in the design.

6.5.8.4.1 ACCESS REQUESTS

1. The AAA shall have access request feature for a supplicant on the network to request access to content that they do not currently have permission to see.

2. The supplicant’s request shall include access credentials, in the form of username and password or security certificate provided by the user, as approved by SFMTA.

3. The supplicant’s request shall include the network address, and information regarding the user's physical point of attachment to the System.

6.5.8.4.2 AUTHENTICATION

1. Authentication performed by the AAA server shall validate that the user’s information is valid using Password Authentication Protocol (PAP). Extensible Authentication Protocol (EAP) is the preferred protocol, except as approved by SFMTA.

2. The user's proof of identification shall be verified, along with the user's network address, account status and specific network service access privileges, as determined by SFMTA.

3. The RADIUS server shall check the user's information against a locally stored Flat File Database in SQL, and Active Directory to verify that the user's credentials are valid.

6.5.8.4.3 AUTHORIZATION

1. Contractor shall design and supply Authorization attributes conveyed to the network element requesting access stipulating terms of access to be granted.

2. Upon receipt and analysis of the access request, the RADIUS server shall then return one of three responses to the requesting network element: 1) Access Reject, 2) Access Challenge or 3) Access Accept.

    a. Access Reject - The user is unconditionally denied access to all requested network resources.

    b. Access Challenge - Requests additional information from the user such as a secondary password, PIN, token, or card. Access Challenge shall be implemented only as directed by SFMTA.

    c. Access Accept - The user is granted access. Once the user is authenticated, the RADIUS server shall also check that the user is authorized to use the network service requested against the SQL database records for the user.

3. All user information (including username, password, MAC address) shall be maintained in SQL.

4. During an Access/Authorization transaction, attributes shall be exchanged to include, but not be limited to:

    a. The specific IP address to be assigned to the user device.

    b. The address pool from which the user's IP should be chosen.

    c. The maximum length that the user may remain connected (permanent or temporary).

    d. An access list, priority queue or other restrictions on a user's access.

    e. L2TP (Layer 2 Tunneling Protocol) parameters.

    f. Virtual Local Area Network (VLAN) parameters.

    g. Quality of Service (QoS) parameters.

    h. Other parameters as required in accordance with Contractor’s design.

6.5.8.4.4 ACCOUNTING

1. Accounting, as specified in RFC 2866 and referenced in Section 7, shall maintain statistical data of Access/Authentication transactions for forensic analysis and for general network monitoring.

2. The accounting data shall be maintained in an SQL database.

3. Accounting reports shall be presented in standard Windows Office compatible format, for investigation and analysis by SFMTA staff. No billing functionality is required.

4. Use of other report formats shall be only as approved by SFMTA Project Manager.

6.5.9 NSS: SOFTWARE

1. Contractor shall supply Software for the NSS as a Commercial Off-The-Shelf (COTS) based product supplied by a commercial company that has demonstrable history of a minimum of five (5) years in business supplying NSS Software with at least two (2) years supplying NSS Software for control systems environments.

2. No custom code shall be permitted on the NSS, except as approved by SFMTA.

3. Contractor shall not use "Freeware", or any other non-commercial code in the NSS.

4. All NSS databases shall be SQL, except as expressly approved by SFMTA.

5. Contractor shall supply all necessary licenses and seats recommended by Contractor for SFMTA to use during full CBTC System implementation and providing a 10% spare capacity to accommodate System growth for workstations and end user devices.

6. Contractor shall maintain, supply, and install all NSS Software and firmware updates for the Term of this Agreement, including all subscriptions and installations as may be required for any Software, firmware, or Hardware required for the firewall, SIEM, RADIUS or TACACS+, IDS, IPS, anti-virus/Malware intrusion protection or any other element supplied as part of the NSS.

6.6 SYSTEM SAFETY AND SECURITY MANAGEMENT CDRLS

Table 6-9: System Safety and Security Management CDRL Table

CDRL #	CDRL Title
06.01	Safety and Security Certification Plan (SSCP)
06.02	Safety and Security Design Criteria
06.03	Safety and Security Design Criteria Conformance Checklist
06.04	Safety and Security Construction Specification Conformance Checklist
06.05	Safety-Related and Security Testing Conformance Checklist
06.06	Safety and Security Rules, Procedures, Training and Drills Conformance Checklist
06.07	Hazard Resolution Conformance Checklist
06.08	Safety and Security Certification Report
06.09	System Safety Program Plan (SSPP)
06.10	Software Assurance Plan (SAP)
06.11	Safety Verification and Validation Plan (SVVP)
06.12	Preliminary Hazard Analysis (PHA)
06.13	System Hazard Analysis (SHA)
06.14	Subsystem Hazard Analysis (SSHA)
06.15	Interface Hazard Analysis (IHA)
06.16	Operating and Support Hazard Analysis (O&SHA)
06.17	Failure Modes and Effects and Criticality Analysis (FMECA)
06.18	Fault Tree Analysis
06.19	Cutover Hazard Analysis (CHA)
06.20	Hazard Log
06.21	Safety Verification and Validation Report (SVVR)
06.22	CBTC Concept of Safety Document
06.23	Interim Safety Report (ISR)
06.24	Final Safety Report (FSR)
06.25	System Security Plan (SSP)

CDRL #	CDRL Title
06.26	Threat and Vulnerability Assessment (TVA)
06.27	Threat and Vulnerability Tracking List (TVTL)
06.28	Cybersecurity Compliance Statement
06.29	Cybersecurity Documentation Manual
06.30	Draft Configuration Manual
06.31	Pre-Final Configuration Manual
06.32	Final Configuration Manual
06.33	List of Applications Installed at Each Facility
06.34	Wireless Network Documentation at Each Facility
06.35	DED Details at Each Facility
06.36	PLC and IED Documentation at Each Facility
06.37	NSS Overview
06.38	NSS Product Data Sheets and Literature
06.39	Secure Coding Documentation
06.40	NSS Functionality Design
06.41	AAA Functionality

7 CODES AND STANDARDS

7.1 PURPOSE

1. This Section provides direction for Contractor to all applicable Codes and Standards in its production of Project designs, installation documentation, implementation and testing.

2. Contractor may substitute alternate Standards such as European (EN) standards, internal corporate process and procedure documents to use. Standards not in this section shall be approved by SFMTA in writing before they may be used.

3. Standards listed in this Section with an asterisk (*) are mandatory and shall not be waived or substituted.

4. Contractor's Program Management Plan shall confirm compliance to Standards that Contractor intends to use relative to their design and implementation.

5. Any deviations or tailoring of Standards provided in this Section shall be presented to San Francisco Municipal Transportation Agency (SFMTA) for review and approval.

6. The Standards being used shall be the approved version at the receipt of Noticed to Proceed.

7.2 CODES AND STANDARDS

7.2.1 GENERAL STANDARDS AND REGULATIONS USED AT SFMTA

1. Contractor shall comply with the following SFMTA, City and US government documents:

    a. All SFMTA policies and procedures listed in Appendix J of the Agreement. SFMTA will update these policies and procedures periodically. Copies which are current at the time of award are included in Appendix J, and SFMTA will provide Contractor with the most current documents as they are updated. Contract shall comply with the most recent version of these policies and procedures it has received.

    b. Federal Contract requirements (see Appendix G to the Agreement), applicable federal and California statutes and regulations, CPUC General Orders, San Francisco Codes and contracting requirements (see Agreement).

7.2.2 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC) STANDARDS

1. Contractor's Quality Assurance (QA) and Quality Control (QC) efforts shall comply with the Standards listed below:

    a. FTA-PA-27-5194-12.1 Federal Transit Administration

    b. ISO 10007 International Organization for Standardization

    c. ANSI/ISO/ASQ Q9000

    d. IEEE Std 730-2014 Institute of Electrical and Electronics Engineers

    e. ANSI/ASQ Z 1.4

    f. ASTM E2587-16 American Society for Testing and Materials

g. National Institute of Standards and Technology (NIST)

7.2.3 SOFTWARE STANDARDS

1. All Software provided by Contractor for the CBTC System, whether Commercial Off-The-Shelf (COTS), application-dependent, or application-independent, shall be tested for their application, at a minimum, in accordance with the following Standards:

    a. CENELEC EN 50128

2. The following standards are applicable for Software Documentation:

    a. CENELEC EN 50128

    b. IEEE Standard 828 Software Configuration Management Plans

7.3 SECURITY STANDARDS

1. Contractor shall demonstrate the CBTC System's compliance to the Security/cybersecurity Standards listed below:

    a. EN 50159:2010, Railway applications - Communication, signaling and processing systems - Safety-related communication in transmission systems

    b. IEEE 62443

    c. IEC 62443 IEC 62443-3-3:2013 Industrial communication networks – Network and System security – Part 3-3: Introduction and general model.

2. Where there are conflicts between applicable Standards, the most stringent/conservative protocol/guideline shall be followed.

3. Contractor may propose alternative equivalent Standards, subject to SFMTA's review and approval

7.4 SAFETY STANDARDS FOR TRAIN CONTROL APPLICATIONS

1. Contractor shall demonstrate the CBTC System's compliance with the following standards:

    a. IEEE 1474.1 (2004)

    b. CENELEC Standards:

        i. EN50126:2017, Railway applications: The Specification and Demonstration of Reliability, Availability, Maintainability, and Safety (RAMS).

        ii. EN50128:2011/A2:2020 Railway applications: Communication, signaling and processing systems – Software for railway and control and protection systems.

        iii. EN50129:2018, Railway Applications: Communications, Signaling, and Processing Systems-Safety Related Electronic Systems for Signaling; and

        iv. EN50155:2001/A1:2002, Railway Applications: Electronic Equipment Used in Rolling Stock.

7.5 CBTC PERFORMANCE AND FUNCTIONAL REQUIREMENTS

1. IEEE 1474.1, 2004 shall be utilized to guide the design and development of the CBTC System.
2. IEEE 1474.2, 2003 shall be utilized to guide the design and development of the user interfaces on the CBTC System.
3. IEEE 1474.3, 2008 shall be utilized with 1474.1 to guide the design and development of the CBTC System.
4. CENELEC EN 50128 shall guide the development and application of functional tests for verification and validation of the CBTC System.

7.6 CALIFORNIA PUBLIC UTILITIES COMMISSION GENERAL ORDERS

1. The following California Public Utilities Commission (CPUC) General Orders are directly applicable to the Contract:
    a. CPUC General Order 127 (GO-127) ATC for Rapid Transit System*
    a. CPUC General Order 164-E (GO-164-E) State Oversight for Rail Transit*
    b. CPUC General Order 175A (GO-175A) Roadway Worker Protection*

7.7 OPERATION AND RAM

1. The following standard shall be applied:
    a. EEMUA 191: Alarm systems - a guide to design, management, and procurement*
    b. ISO 55000: Asset management — Overview, principles, and terminology*
    c. ISO 55001: Asset management — Management systems — Requirements*
    d. NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems
    e. MIL-STD-1629 - Procedures for Performing a Failure Mode, Effects and Criticality Analysis
    f. MIL-HDBK-338 Electronic Reliability Design
    g. IEC 61025:2006 – Fault Tree Analysis
    h. IEC 61078:2006 – Analysis Techniques for Dependability – Reliability Block Diagram and Boolean Methods
    i. IEC 61165:2006 – Application of Markov Techniques
    j. RIAC-HDBK-217 Reliability Prediction Models
    k. EN50126: Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
    l. MIL-HDBK-338B, Electronic Reliability Design Handbook
    m. MIL-HDBK-470A Designing and developing Maintainable Products and Systems.

n. MIL-HDBK-781A Handbook for Reliability Test methods, Plans, and Environment for Engineering

7.8 DEVELOPMENT, QUALIFICATION AND PRODUCTION

1. Contractor shall comply with the following Standards for the design and development of the CBTC System:

    a. IEEE 15288 - Systems and Software engineering - System life cycle processes

    b. American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications and Signaling Manual 2021 Edition

7.9 CBTC EQUIPMENT STANDARDS

7.9.1 EQUIPMENT STANDARDS

1. Contractor shall demonstrate the CBTC System's compliance to the following Standards for the wayside Equipment installed:

    a. International Electrotechnical Commission (IEC) 60259, Degrees of protection provided by enclosures (IP Code)

    b. National Electrical Manufacturers Association (NEMA) 250, Enclosures for Electrical Equipment

7.9.2 DATA COMMUNICATION SYSTEM (DCS) STANDARDS

1. Contractor shall demonstrate the CBTC System's compliance to the following Data Communications Subsystem (DCS) Standards:

    a. IEC 60529

7.9.3 POWER AND GROUNDING STANDARDS

1. Contractor shall demonstrate the CBTC System's compliance with the following power and grounding Standards for CBTC System Equipment required to be grounded:

    a. IEEE C2, National Electrical Safety Code*

    b. NEC 2020

    c. NFPA 130, "Standard for Fixed Guideway Transit and Passenger Rail Systems"

    d. Underwriters Laboratories (UL) 1, Standard for Safety Flexible Metal Conduit

    e. UL 50, Standard for Safety Enclosures for Electrical Equipment

    f. UL 1685, Reference Standard for Electrical Wires, Cables, and Flexible Cords

    g. UL 2556, Wire & cable test methods

    h. UL 2885, UL Outline of Investigation for Acid Gas, Acidity and Conductivity of Combusted Materials and Assessment of Halogens

i. IEEE C37.90a:2012, "Guide for Surge Withstand Capacity Tests"

7.9.4 ENVIRONMENTAL STANDARDS

1. Contractor shall comply with the following Environmental Standards:

   a. AREMA 11.5.1 (for Wayside Zone Controller and Object Controller)

   b. CENELEC EN 50125-1 Railway applications - Environmental conditions for equipment - Part 1: Rolling stock and on-board equipment

   c. IEC 61373, Railway applications - Rolling stock Equipment - Shock and vibration tests

   d. IEEE 1478, Standard for Environmental Conditions for Transit Railcar Electronic Equipment

   e. Telcordia GR-63 CORE Seismic Standard

7.9.5 ELECTROMAGNETIC INTERFERENCE (EMI)/ ELECTROMAGNETIC COMPATIBILITY (EMC) STANDARDS

1. Contractor shall demonstrate the CBTC System's compliance with the following EMI/EMC Standards for EMI/EMC activities:

   a. CENELEC EN 50121 - Railway Electromagnetic Compatibility

7.10 CODES AND STANDARDS CDRLS

Table 7-10: Codes and Standards CDRL Table

CDRL #	CDRL Title
N/A	No CDRLs in this section

8 DEPLOYMENT, MIGRATION AND ACCEPTANCE

8.1 PURPOSE

1. This Section provides the requirements that govern the Deployment and Migration of its Equipment and System to enable cutover of the CBTC System into existing SFMTA operations.

    a. Deployment refers generally to all activities required to introduce Contractor Equipment into SFMTA operations culminating in Commissioning.

    b. Migration refers to activities that transition SFMTA's rail service from the legacy ATCS to the new CBTC System onboard Vehicles and along the Wayside, including any required training.

8.2 IMPACT ON SFMTA OPERATIONS

1. The Project is taking place on an active railway used by over a hundred thousand riders each Day and the Contractor and SFMTA Project Manager must make every effort to avoid impacting SFMTA's Revenue Service. Contractor shall request the minimum amount of access time needed to accomplish the work and follow SFMTA's Track and Tunnel Access Policy's requirements for obtaining track clearance permits and advance scheduling of work requiring SFMTA to curtail its Revenue Service.

2. In developing the Project Schedule as described in Section 3.2.4, Contractor will need to make assumptions about the availability of SFMTA Furnished Items, such as tracks, tunnels, facilities, personnel and assets. Contractor shall make conservative schedule assumptions which minimize the use of these SFMTA Furnished Items and impact to SFMTA's operations and maintenance activities.

3. Contractor shall cooperate with SFMTA to develop, plan, and schedule any required CBTC System installation and testing activities to coordinate with ongoing SFMTA Preventive Maintenance, other capital improvement programs, inspections, and other activities that must be performed in non-revenue hours. Contractor shall participate in SFMTA-led coordination meetings for that purpose.

4. In some cases, it will become unavoidable that SFMTA will need to reschedule Project activities to resolve conflicts between the Project activities and critical transit service or other maintenance or capital improvement activities. Contractor shall accommodate SFMTA's requests to reschedule Project activities.

8.3 PROJECT PHASES

1. Contractor shall employ a phased approach to the Deployment and Migration of the CBTC System consisting of the ten Phases below. These Phases correspond to the Milestone Schedule included in Appendix C to the Agreement. The geographic limits of the seven Deployment Phases are specified in Section 2.3.

    a. System Design

    b. Central Equipment Delivery and Installation, including simulators, tools, documentation and training

    c. Onboard Equipment Fitting

    d. Pilot Deployment Phase

    e. Subway Replacement Deployment Phase

f. N Expansion Deployment Phase

g. T Expansion Deployment Phase

h. K&M Expansion Deployment Phase

i. J Expansion Deployment Phase

j. L Expansion Deployment Phase

2. Contractor shall develop and provide a Deployment and Migration Plan [CDRL] that describes how the CBTC System will be installed, tested, and Commissioned in a phased approach to minimize impacts on SFMTA operational, infrastructure and resource impacts.

3. The Deployment and Migration Plan shall describe:

   a. The phased Deployment and Migration into Revenue Service for CBTC System Vehicle Equipment on all equipped SFMTA revenue Vehicles.

   b. The phased Deployment and Migration into Revenue Service for CBTC System Central Office Equipment including both Primary and Back-up locations.

   c. The phased Deployment and Migration into Revenue Service for CBTC System Wayside Equipment including Subway, At-Grade, and Test Track locations in accordance with Section 2.3.

   d. Operational or maintenance requirements for all CBTC System Equipment installed but not in use during Revenue Service operations (prior to Conditional Acceptance), including any use of this Equipment in an in-service monitoring state.

   e. Migration strategy for the CBTC Subsystem Automatic Train Supervision (ATS), including any permanent or temporary processes or procedures, and/or modifications to existing SFMTA SOPs, processes and procedures required to support the ongoing in service SFMTA operations.

   f. Migration strategy for CBTC System (ATO) operations in the Subway including any permanent or temporary processes or procedures, and/or modifications to existing SFMTA SOPs, processes and procedures to support the ongoing in service SFMTA operations.

   g. Migration strategy of the technical infrastructure including servers, network equipment and other systems and components. This migration strategy shall require review and processing through the Technology Change Advisory Board Process.

4. The Deployment and Migration Plan shall further describe the requirements for Deployment and Migration activities during the Deployment Phases, and how these requirements are implemented and verified to support the phased Deployment and Migration of the System.

5. Each Deployment Phase shall include the following periods, listed below:

   a. Construction Final Design Period

   b. Pre-Installation Period

c. Installation (also called Construction, includes the buildout of the technical infrastructure) Period

d. Testing and Commissioning Period

e. Pilot Operating Period (for Pilot Phase only)

f. Warranty Period

6. The Deployment and Migration Plan shall also describe the process for Final Acceptance of the System, including the requirements for Final Acceptance contained in this Section, how these requirements will be demonstrated and verified for SFMTA's final approval.

7. Contractor shall include Deployment and Migration activities within the Project Schedule.

8.3.1 DESCRIPTION OF SYSTEMWIDE PHASES

1. Contractor shall organize its systemwide Deployment into the following Phases. Final Acceptance is not a Phase but is a significant Milestone described in this Section.

8.3.1.1 SYSTEM DESIGN

1. Contractor shall divide design implementation divided into a common System Design Phase at the start of the Project and multiple Construction Final Design Periods, one for each Deployment Phase, as described in Section 4.2 (Design Lifecycle).

2. System Design is comprised of Conceptual Design, Preliminary Design, and System Final Design. Each of these stages end in a Design Review and the approval of each stage of design by SFMTA. Specific requirements for each stage are described in Section 4.2.

3. Contractor shall not proceed with the next Phase until the System Final Design has been accepted by SFMTA.

4. Contractor shall identify any long lead items during this Phase and procure them as early as necessary to ensure they arrive before the applicable Installation Period.

8.3.1.2 CENTRAL EQUIPMENT DELIVERY AND INSTALLATION

1. The Central Equipment Delivery and Installation Phase includes a Construction Final Design Period meeting the requirements in Section 8.3.2.1 which provides for the detailed construction designs, schematics, installation instructions are developed for the Central Equipment and network installation.

2. Contractor shall supply one complete set of primary Control Center Equipment, as described in Section 27.7 (CBTC Control Center Equipment Requirements), which shall be delivered, installed and fully Commissioned prior to the start of the Pilot Operating Period.

3. Contractor shall supply a second complete set of secondary Control Center Equipment, simulators, tools and documentation, as described in Section 21 (Simulators and Tools) and Section 27.7 (CBTC Control Center Equipment Requirements), which shall be delivered and installed and fully Commissioned prior to Subway Cutover.

4. Contractor shall supply all its back-office and centralized network infrastructure as described in Section 26 (Communications) as part of this Phase.

5. Contractor shall be present for the installation of the Equipment delivered during this Phase to ensure it has been installed in accordance with Contractions instructions and specifications.

6. The Milestone for this Phase also includes the delivery of simulators, tools, documentation and training as provided for in the Contract Specifications.

8.3.1.3 ONBOARD EQUIPMENT FITTING

1. Contractor shall Equip at least one LRV as the "Test Car", to demonstrate compliance with Contract Specifications and to confirm/refine installation procedures. SFMTA will generally hold that LRV out of service and dedicate it for CBTC Project testing. The Test Car may also be the "First Car" as defined below.

2. Contractor shall work collaboratively with the Vehicle Installer to demonstrate at least one successful "First Car" LRV installation and full functionality of the installed onboard Equipment prior to and as a condition for initiating installation to the LRV fleet. Contractor may participate in multiple "First Car" LRV installations as needed to solidify installation procedures.

3. Contractor shall Equip at least one Heritage Vehicle and one Maintenance Vehicle as the "Test Vehicles", to demonstrate compliance with Contract Specifications and to confirm/refine installation procedures. SFMTA will generally hold those Vehicles out of service and dedicate it for CBTC Project testing. The Test Vehicles may also be the "First Vehicle" as defined below.

4. Contractor shall work collaboratively with the Vehicle Installer to demonstrate at least one successful "First Vehicle" for the Heritage and Maintenance Vehicle installation and full functionality of the installed onboard Equipment prior to and as a condition for initiating installation to the rest of the Heritage and Maintenance fleets. Contractor may participate in multiple "First Vehicle" installations as needed to solidify installation procedures.

5. Contractor shall refine its Vehicle Equipment design, installation instructions and procedures in response to conditions observed during the "First Car" or "First Vehicle" installation or other installations, to improve the quality or efficiency of the installation. All documentation shall be revised to include these refinements. Design modifications arising from this process shall be reviewed through the CBTC Change Control Process described in the PMP.

6. At least one of Contractor's engineers shall be present on-site at any time that Vehicle installations are being performed, to act as a resource for SFMTA and Installers.

7. Contractor shall provide QA services for every Vehicle installation as described in Section 5 (Quality Assurance and Quality Control).

8. Contractor shall Equip a minimum of 100 LRVs and perform any tests necessary to ensure they are ready for Revenue Service before the start of the Pilot Operating Period.

9. Contractor shall Equip all SFMTA LRVs and perform any tests necessary to ensure they are ready for Revenue Service before and as a condition for Subway Cutover.

10. Following successful Contractor testing, SFMTA will inspect and accept each LRV installation before admitting the LRV for Revenue Service.

11. Contractor shall identify temporary or obsolete onboard train control Equipment that is not necessary for CBTC System operation for removal, including but not limited to Contractor provided temporary cutover switches, cutover boxes and wiring, following Subway Cutover.

12. During this Phase SFMTA will install Contractor's Equipment on the Heritage and Maintenance Vehicles included in the exercised Options. Contractor shall participate in installation activities as described in Sections 2.4.2 (Heritage Fleet) and 2.4.3 (Maintenance Vehicles).

13. All Heritage and Maintenance Vehicle installation shall be completed before Subway Cutover.

8.3.1.4 FINAL ACCEPTANCE

1. Upon successful completion of the Warranty Period for the final Phase and delivery of all final System documentation, Contractor may then apply for Final Acceptance.

2. SFMTA will check the following criteria are met before issuing Final Acceptance.

    a. All Equipment, tools, Materials, Software provided for in this Contract have been delivered, installed, tested and Commissioned.

    b. All Safety Certification documentation has been finally approved and received by SFMTA and CPUC.

    c. All Deliverables, trainings, manuals, plans and documents provided for in this Contract have been approved and received by SFMTA.

    d. All Work, except for ongoing Support, has been completed.

    e. Contractor has provided SFMTA with verification that all Contract requirements have been met.

    f. All System defects, including Hardware defects and Software Bugs identified prior to Final Acceptance have been resolved in full compliance with Contract Specifications.

    g. Contractor shall complete all "punchlist" items provided to Contractor by SFMTA as a condition of Final Acceptance. The punchlist items shall be the list of defects, Software Bugs, Open Items and NCRs as reported on the Monthly Progress Report (see Section 3.6.1).

    h. Contractor has reviewed its Obsolescence Management Plan with SFMTA, as provided for in Section 14.

    i. All Warranty Periods have ended.

3. SFMTA's Final Acceptance of the System closes the Procurement Term of this Contract. For the remainder of the Contract Term (the "Support Term"), Contractor shall perform Support Services in accordance with the requirements in Section 32.

8.3.2 DESCRIPTION OF DEPLOYMENT PHASES

1. Contractor shall organize the Work in each of the Deployment Phases according to the following work periods. With the exception of the Pilot Operating Period, which is only included in the Pilot Deployment Phase, these periods repeat for each Deployment Phase. The Deployment Phases are further described in Section 2.3 (Geographic Scope and Deployment Phases).

8.3.2.1 CONSTRUCTION FINAL DESIGN

1. Each Deployment Phase will begin with a Construction Final Design Period. During this period, detailed construction designs, schematics, installation instructions are developed in order to produce

plans to turn over to the Wayside Installer. The Construction Final Design objectives are further described in Section 4.2.4 (Construction Final Design Objectives).

2. The Construction Final Design Period will end upon SFMTA's Acceptance of the Construction Final Design for that Deployment Phase, following a successful Construction Final Design Review.

8.3.2.2 PRE-INSTALLATION (DELIVERY)

1. Contractor shall allot nine months in each Deployment Phase schedule (the "Pre-Installation" Period) between the Construction Final Design Review and the start of installation work by an Installer, to provide time for the SFMTA to contract with Installer(s). Additional requirements for Contractor's participation in the Installer selection process are provided in Section 8.5.1 (Contractor's Responsibilities with Respect to Installers).

2. For each Deployment Phase, Contractor shall deliver CBTC Equipment prior to the start of installation. Contractor may use the Pre-Installation period for delivery, inspection, and staging.

3. Contractor shall deliver the CBTC System Wayside Equipment and Software as required in the Project Schedule.

4. Contractor shall provide adequate time in the Project Schedule for procurement of Materials, inventory and delivery.

5. Contractor shall review the schedule of long lead procurement items with SFMTA as required to meet the Project Schedule.

6. Contractor shall deliver any network equipment, access points, or network infrastructure (except SFMTA Furnished Items as described in Section 9 (SFMTA Furnished Items) and SFMTA-approved Shop Materials furnished by Installer), that are necessary to connect the CBTC Equipment installed during the Deployment Phase with the central CBTC Equipment, so that together with the Vehicles a fully functional CBTC System is operable within the geographic limits specified in Section 2.3 (Geographic Scope and Deployment Phases), as provided in the Contract Schedule.

8.3.2.3 INSTALLATION (CONSTRUCTION)

1. For each Deployment Phase, Contractor shall monitor Installation Activities performed by SFMTA's Installer to ensure that work is performed correctly.

2. Contractor shall submit a Wayside Installation Plan [CDRL] that describes Contractor's design, development, planning and Support for the installation of wayside Equipment.

3. Contractor shall include all activities expected to be completed by the Wayside Installer to support Deployment and Migration in the Wayside Installation Plan.

4. Contractor shall plan and develop installation documentation to support wayside Equipment, including the Back-end Infrastructure and network installation, as described in Section 8.4.

5. Contractor shall develop and configure the CBTC Software and Furnish all Equipment and Materials necessary to install Contractor's System on SFMTA premises, except SFMTA Furnished Items as described in Section 9 and SFMTA-approved Shop Materials.

6. Contractor shall perform Quality Control oversight to installation as described in Section 5 (Quality Assurance and Quality Control).

7. Contractor shall witness all wayside Post-Installation Check Out (PICO) tests and verify installation was performed correctly or report discrepancies as specified in Section 31.7.2 (Post-Installation Check Out Testing).

8. Contractor shall conduct joint readiness reviews with SFMTA staff and the Wayside Installers as described in Section 4.2.6 (Delivery and Installation).

8.3.2.4 TESTING AND COMMISSIONING

1. Following the installation of the Equipment provided for each Deployment Phase, Contractor shall conduct the testing described in Section 31 (Testing and Commissioning). This testing activity will culminate in Commissioning tests, after which Contractor will present SFMTA with the required safety and other certifications necessary to operate the System in Revenue Service.

2. Contractor shall perform unit testing, subsystem testing and integrated System testing of all CBTC Software and Hardware components.

3. Contractor shall develop System subsystem and integration test cases and documentation, including success/failure criteria, and trace all test cases back to the functional and derived System requirements.

4. Contractor shall conduct a System Factory Acceptance Test (FAT) to verify and validate that the CBTC System Hardware and Software performs as required.

5. Contractor shall perform unit testing, subsystem tests and integrated testing between all required systems and subsystems operating with full CBTC System functionality using the Project Software and Hardware components as described in Section 31 (Testing and Commissioning).

6. For every Software release, after the FAT and before the Software is loaded onto SFMTA System, Contractor shall perform two live Software demonstrations as described in Section 31.4.6 (Software Release Demonstrations) to demonstrate the new implemented or modified functionality to SFMTA's employees. One demonstration is performed remotely using the Software installed on Contractor's factory equipment and one is performed on-site using SFMTA's simulator(s).

7. Contractor shall test the CBTC System to ensure that the CBTC System performs as required by the Contract and meets all Safety Assurance requirements required for Revenue Service as specified in Section 6 (System Safety and Security Management).

8. Contractor shall perform Field Testing as described in Section 31.7 (Field Testing).

9. The Testing and Commissioning Period shall end when SFMTA accepts the Commissioning of the CBTC System delivered in each Deployment Phase. Revenue Service cannot commence until the successful certification by the California Public Utilities Commission (CPUC) as required in Section 7.6 (CPUC General Orders).

8.3.2.5 PILOT OPERATING PERIOD

1. The purpose of the Pilot Operating Period is to demonstrate the functionality and capabilities of a complete CBTC System, with central, wayside and Vehicle subsystems fully operational, in a lower risk environment before attempting the Subway Cutover. The Pilot Operating Period is also a part of the requirements development process. The Pilot Operating Period will begin with the Commissioning of the portion of the System delivered during the Pilot Deployment Phase. SFMTA will give approval to begin Pilot Revenue Service (Milestone 4-7) when:

a. All Equipment necessary to operate the System in Revenue Service over the Pilot geographic area, including the primary Control Center Equipment and the test track at MME yard, has been delivered, installed, tested and Commissioned.

b. At least 100 LRVs have been equipped, tested and are ready for Revenue Service.

c. All Safety Certification documentation and approvals from CPUC have been delivered to SFMTA.

d. SFMTA has approved a Support Management Plan as specified in Section 32.

e. Contractor has provided a fully functional NSS System and Back-end Infrastructure, including tools provided to support technical performance and security, to ensure System monitoring.

f. Contractor has provided all designs, Equipment, processes, procedures and staffing to support the dual operations for the new CBTC System operating in parallel with the existing ATCS System.

g. SFMTA has approved the activation of all Third-Party System integrations necessary to operate the System in Revenue Service.

2. During the Pilot Operating Period, SFMTA will operate the portion of the System which has been delivered during the Pilot in Revenue Service, subject to the following conditions:

a. The design of the System is not final. Modifications to the System remain the responsibility of Contractor. Contractor may make modifications necessary to correct defects, respond to SFMTA feedback, or to accommodate the testing and Commissioning of other portions of the System.

b. SFMTA and Contractor will closely monitor the performance and Reliability of the System during this period. SFMTA may revert to manual line-of-sight operating rules if System Performance is impacting service delivery.

c. The existing ATCS will still be in operation in the Market Street and Central Subways during the Pilot Operating Period. Contractor shall design a method of operating Trains using both its CBTC System and the ATCS.

d. Transitions between the CBTC System and ATCS shall occur at the Ferry Portal and Central Subway Portal.

e. SFMTA will perform first and Second-level Maintenance for the Commissioned portion of the System, including the CBTC System infrastructure and network. Contractor shall monitor measures of maintenance performance such as Mean Time to Repair, Mean Time to Restore, and Mean Time to Respond, as well as hours spent on Preventive Maintenance.

3. Contractor shall demonstrate to the SFMTA during the Pilot Operating Period, using the installed Equipment and Software furnished during the Pilot Deployment Phase:

a. All ATS functions described in Section 17 that are required for Street Territory.

b. All Street Mode functionality including surface Interlocking functions described in Sections 16.2, 16.3.1, 16.3.1.3, 17.5.1.4, 19.6, 19.7, 22.2, 22.3, 22.4, 22.6.2, 22.6.3, and 22.6.4.

c. Communication between Vehicle onboard systems, wayside Equipment and Central Equipment

d. ATO functions demonstrated using the MME test track

e. Integration with the traffic signals as described in Section 28.8

f. Onboard system functionality

g. Heritage and Maintenance Vehicle operations

h. AMS

i. NMS

j. Train Depart Local Control Consoles

4. During the Pilot Operating Period, Contractor shall:

a. Deliver on-the-job training to SFMTA staff during this period and provide Support Services described in Section 32 (Support Services) for the Commissioned section of the System.

b. Supply spare parts as described in Section 13 (Warranty and Spare Parts). Contractor shall not be paid Monthly Support Fees until Conditional Acceptance of the Pilot Phase.

c. Lead a monitoring program which tracks both System defects and human factors that contribute to meeting Reliability targets.

d. Develop and execute a Failure Reporting and Corrective Action System that tracks failures and resolutions of issues identified during the Pilot Operating Period.

e. Correct design defects, omissions, and other issues if the System does not meet performance or other Contract requirements.

f. Adjust the System configuration, procedures, manuals, instructions, training or other Deliverables, in consultation with SFMTA, as necessary to ensure the CBTC System meets the Performance Targets specified in the Contract by the end of the Initial RAM Demonstration.

5. Contractor shall allot 60 days during the Pilot Phase in the Project Schedule, starting on the first day of the Pilot Operating Period, for SFMTA operations and maintenance staff to provide comments on the user interfaces to the System.

6. On the 70th day of the Pilot Operating Period, SFMTA will transmit its comments to the Contractor. SFMTA and Contractor shall review and revise the following CDRLs compared to the conditions experienced during the Pilot Operating Period and the comments received:

a. ATS Human Factors Analysis and Review Document

b. ATS Alarm List and Priorities

c. GUI Displays Description

d. ATS Screen Displays for the Video Wall

e. ATS Mobile Application Design Description

f. AMS Alarm List for ATS

g. AMS Alarm List and Priorities

h. AMS Reports Description

i. NMS Alarm List and Priorities

j. NMS Reports Description

k. TOD Human Factor Analysis

l. GUI Specification for TOD

m. Workstations Human Factor Analysis

n. API Design Document

o. Traffic Signal Controller ICD

7. SFMTA will direct Contractor to make changes to the Software and design based on the revisions described in the preceding paragraph following an iterative design review. Contractor shall make the directed changes and shall not be entitled to a price increase for those changes as long as:

   a. The changes are to Software functionality described in one of the documents listed in 8.3.2.5 paragraph 7a-o, above.

   b. The changes do not result in a change to the requirements in these Contract Specifications

   c. The changes do not result in more than 6 months of Software development effort.

8. Contractor shall provide SFMTA with an hour estimate for the Work to implement the changes described in this Section.

9. Contractor shall implement the changes described in this Section by incorporating them into the next planned Software release after the Pilot Operating Period, or as agreed with SFMTA.

10. The Pilot Operating Period will continue until the Subway Cutover, where the Pilot Phase and Subway Replacement Phase will begin their Warranty Periods concurrently. The Pilot Deployment Phase shall not begin its Warranty Period before the Subway Replacement Phase Warranty Period starts.

8.3.2.6 SUBWAY CUTOVER

1. During the Subway Replacement testing and Commissioning, there may be multiple cutover events between Contractor's CBTC System and the existing ATCS, for CBTC System testing purposes and revenue operations recommencement. Immediately following Commissioning, Contractor shall conduct a final cutover ("Subway Cutover"), after which the CBTC System will be left in operation during Revenue Service.

2. Contractor shall not proceed with Subway Cutover without SFMTA authorization.

3. The following requirements shall be met prior to Subway Cutover (Milestone 5-7):

a. All Control Center Equipment, both primary and secondary, has been delivered, installed, tested and Commissioned.

b. All simulators, tools, documentation and Equipment necessary to operate the System have been delivered, installed, tested and Commissioned.

c. All LRVs have been equipped, tested and are ready for Revenue Service.

d. The functionality meeting the requirements for Heritage and Non-Revenue vehicles specified in Sections 2.4.2 and 2.4.3 have been delivered, tested, and demonstrated.

e. All issues identified during the Pilot Operating Period have been resolved.

8.3.2.7 WARRANTY PERIOD

1. The Warranty Period for each Deployment Phase, except the Pilot Phase as described in Section 8.3.2.5, begins upon the Commissioning of the portion of the CBTC System delivered in that Phase and continues for eighteen months.

2. Warranty Periods for multiple Deployment Phases may overlap, but each Deployment Phase must be covered under the Warranty Period for a total of eighteen months.

3. During the eighteen-month Warranty Period for each Deployment Phase, Contractor shall:

    a. Replenish spare parts for the System and provide the Warranty Services as specified in Section 13 (Warranty and Spare Parts) and Section 32 (Support Services).

    b. Correct any defects or bugs in System, tools, Materials, simulators, or Software discovered during the Warranty Period. These items will be added to Contractor's punchlist to be completed before Final Acceptance.

4. SFMTA will not pay Contractor Monthly Support Fees during the Warranty Period. The earliest Contractor will be eligible to receive Monthly Support Fees on the first of the nineteenth month following Subway Cutover. Monthly Support Fees shall be phased in depending on the number of Deployment Phases which have been Conditionally Accepted, according to the Monthly Support Fee schedule in Appendix B to the Agreement.

5. At the end of the Warranty Period for each Deployment Phase, Contractor shall begin performing Support Services for the portion of the CBTC System in Revenue Service and out of Warranty in accordance with the requirements in Section 32 (Support Services).

6. There shall be no lapse in Support/Warranty Services starting from the day each Phase is Commissioned until the expiration of the Contract Term.

8.3.2.8 CONDITIONAL ACCEPTANCE

1. Contractor may apply for Conditional Acceptance of the portion of the CBTC System delivered during a Deployment Phase after the applicable Warranty Period for that Phase has ended.

2. Contractor shall meet the following conditions prior to each Deployment Phase's Conditional Acceptance:

a. All Equipment necessary to operate the System in Revenue Service over the Deployment Phase's geographic area as defined in Section 2.3, has been delivered, installed, tested and Commissioned.

b. All Safety Certification documentation and approvals from CPUC have been received by SFMTA.

c. Contractor shall submit all Deliverables applicable to each specific Deployment Phase for Acceptance by SFMTA. These Deliverables include any site-specific installation, testing training or compliance documentation.

d. Contractor shall provide written verification that all Contract requirements applicable to each specific Deployment Phase have been met.

e. Contractor shall fix, repair and otherwise resolve all System defects, including Hardware defects and Software Bugs, found during preceding verification and test activities.

f. Contractor shall make the statement as described in Section 8.5.1.1 (6) verifying that the installation work was done correctly and in accordance with its specifications and that all Installer punchlist items, if required have been inspected by Contractor and are completed satisfactorily.

4. SFMTA may, at its sole discretion, give Conditional Acceptance with minor Open Items that do not impact the safety or core operations of the System. These items will be added to Contractor's Punchlist. Notwithstanding SFMTA approvals as to each Phase, Contractor shall resolve all System defects as a condition of Final Acceptance of the System.

8.3.3 RAM DEMONSTRATION

1. Contractor shall conduct two RAM Demonstrations to demonstrate that the delivered System, or portion of the System in Revenue Service, meets the Performance Requirements specified in these Contract Specifications and the Agreement.

2. During the RAM Demonstration, the Contract shall conduct Reliability and Maintainability Demonstration Testing as specified in Section 30.6.5 (RAM Verification and Testing).

3. Contractor shall continue the RAM Demonstration until all Performance Targets specified in Appendix I to the Agreement have been met for a period of six consecutive months.

   a. The Initial RAM Demonstration shall begin at Subway Cutover.

   b. The Final RAM Demonstration shall begin upon Commissioning of the final Deployment Phase.

4. SFMTA will operate and maintain the Commissioned portions of the System in Revenue Service during each RAM Demonstration. Contractor shall provide continuous reporting and analysis of performance data using the methodology specified in Section 30.

5. Contractor shall support SFMTA's evaluation of the System Performance against the Performance Targets specified in Appendix I to the Agreement to confirm they are being met each month.

6. If the System Performance fails to meet the Performance Targets at any time during the RAM Demonstration, that RAM Demonstration ends and Contractor shall restart the RAM Demonstration.

7. If a RAM Demonstration has failed, any Support Fees due to Contractor shall be reduced according to the procedure in Appendix B2.3.3.3 to the Agreement (Adjustment for Failure to Demonstrate RAM) until the RAM Demonstration has been completed.

8. During the RAM Demonstration, Contractor shall adjust the System, Software, documentation, manuals and training Materials, at no additional cost to SFMTA, as needed to enable the System to meet the required Performance Targets, or to address bugs and defects identified during the RAM Demonstration or earlier.

9. Contractor shall not Commission subsequent Phases while a RAM Demonstration is in progress. If a RAM Demonstration fails and must be restarted, Contractor may Commission new Phases into Revenue Service upon written approval from SFMTA before restarting the RAM Demonstration. These Phases will be added to the evaluation of the RAM Demonstration once it restarts.

8.4 CONTRACTOR ACCESS

1. Contractor shall follow the current SFMTA Track and Tunnel Access Procedures when scheduling and performing work which requires access to SFMTA's Right of Way. A copy of these Procedures is provided in Appendix J to the Agreement.

2. Contractor shall develop and submit a Construction Safety Program Plan [CDRL] to SFMTA with provisions for Roadway Worker Protection, Employee Occupational Health & Safety (OSHA), and public safety.

3. Contractor shall ensure that the Construction Safety Program Plan is approved by SFMTA before starting work on any platform site or portion of the trackway.

8.5 INSTALLATION

8.5.1 CONTRACTOR'S RESPONSIBILITIES WITH RESPECT TO INSTALLERS

1. Contractor shall not perform any Equipment installation that requires a California contractor's license, or any Equipment installation on LRVs. These activities shall be referred to as "Installation Activities."

2. The SFMTA will contract with Installers to perform the Installation Activities, but Contractor shall supervise and inspect the Installers' work to ensure that work is performed correctly.

3. Contractor shall coordinate schedules, documentation review periods, installation and test requirements and Equipment delivery between Contractor and SFMTA Installers through SFMTA. The coordination shall be described in the Project Management Plan.

4. Contractor shall not direct the work of SFMTA's Installers. The SFMTA is responsible for the conduct and work of its Installers. Contractor's written installation instructions shall be provided to SFMTA, who will approve and provide to its Installers. If Contractor observes a situation in the field for which it is necessary to issue verbal instructions, Contractor shall notify the SFMTA worker in charge, who will direct the Installer.

8.5.1.1 WAYSIDE INSTALLERS

1. SFMTA will contract with one or more Wayside Installers, who will install all Equipment excluding the Vehicles.

2. Following each Construction Final Design Period, SFMTA will separately contract for the installation work for that Deployment Phase. SFMTA may combine one or more of the Deployment Phases for installation in its sole discretion.

3. SFMTA will conduct a separate Installer selection process for each contract. Contractor shall assist SFMTA in selecting the Installers.

4. For each Installer selection process, Contractor shall:

    a. Prepare the complete design package(s) described in Section 4.2.4 (Construction Final Design Objectives) to be bid to installers.

    b. Draft the Installer scope of work to be included in the bid package.

    c. Draft a list of minimum qualifications and selection criteria for potential Installers based on Contractor's experience with other systems. Minimum qualifications are mandatory for all applicants and selection criteria are scored during the competitive bid process.

    d. Participate in SFMTA's selection process, including supplying a project team member to serve on the selection committee.

5. Contractor shall coordinate with the Installers to include all Installer interfaces and activities in the Project Schedule necessary to ensure Contractor has sufficient time and access to inspect the installation work during installation and critical hold points to confirm installation work is correctly performed.

6. Contractor shall update the Project Schedule in response to Installers' forecasted and actual Installation Activities dates and durations.

7. During installation Contractor shall maintain the Project Schedule. SFMTA's Installer will submit weekly updates to ensure that Installation Activities are performed in accordance with the Project Schedule and Project Management Plan. Contractor shall promptly alert SFMTA if the Installation Activities are not progressing as scheduled.

8. Contractor shall submit a Wayside Installation Plan [CDRL] as part of the Construction Final Design Review for each Deployment Phase that:

    a. Describes the Deployment Phase and the physical boundaries of the work to be performed.

    b. Lists the Bill of Materials required to be installed, including Shop Materials. Shop Materials shall be presented separately from Contractor-provided Materials.

    c. Lists the Drawings and design documents to be used as reference to the installation.

    d. Lists all detail installation Drawings and plans required by the Installer.

    e. Lists all anticipated Special Tools or Equipment anticipated to be used by the Installer. This list shall include vendor, calibration, or other details.

    f. Develops the Hazard list for any Equipment to be installed.

    g. Lists and describe Inspection and Testing Requirements Installer should perform. Contractor should specify responsibility of all testing to be performed including responsibility of who shall create the test procedure and who shall conduct the testing.

h. Lists all SFMTA Furnished Items anticipated to be modified by the Wayside Installer.

i. Includes a schedule for installation which accounts for SFMTA access requirements and clearance process. Contractor shall provide its best estimate for these Installation Activities and coordinate with SFMTA to confirm agreement with these estimates with the Installer.

j. Describes Contractor QA and QC processes to verify Wayside Installation is constructed in compliance with approved designs.

9. Contractor shall notify SFMTA if there are major discrepancies in installation that prevent SFMTA from using the installed works in Revenue Service within the time specified in Section 10.2.1 of the approved Project Management Plan.

10. Within the time specified in the Section 10.2.1 of the approved Project Management Plan, Contractor shall either:

    a. Confirm to SFMTA that all installation work was done properly and in accordance with the approved designs and Contractor's specifications, or

    b. Submit a complete list ("Installer Punch List") of items that need to be remedied to achieve Conditional Acceptance.

11. Following SFMTA Conditional Acceptance of the Deployment Phase, Contractor shall be accountable to SFMTA for ensuring the System Reliability, Availability, and Maintainability Performance Targets of the CBTC System are achievable using the installed works.

12. Contractor shall not be accountable for failures resulting from items it identifies in Installer Punch Lists, unless those items have been remedied prior to the failure.

13. If Contractor issues an Installer Punch List, and SFMTA or its Installers perform rework to address the items in the Installer Punch List, Contractor shall perform any applicable retests to confirm the items on the Installer Punch List have been remedied.

14. Following its performance of applicable retests, Contractor shall either:

    a. Confirm to SFMTA that all installation work was done properly and in accordance with approved designs and Contractor's specifications, or

    b. Submit another Installer Punch List as described in this Section.

8.5.1.2 VEHICLE INSTALLER

1. The requirements in this Section shall apply to all Vehicle installations, including LRV4s, Heritage and Maintenance Vehicles.

2. SFMTA will contract with a separate Vehicle Installer, who will be responsible for installing Equipment on the Vehicles. Contractor shall submit a Vehicle Installation Interface [CDRL] list of all anticipated physical interfaces including preliminary Equipment sizes, Trainline and mounting requirements for approval by SFMTA.

3. Contractor shall coordinate and develop with SFMTA and SFMTA Vehicle Installer, the activities and durations required for Vehicle Installation Activities. Contractor shall include this coordinated schedule within the Project Schedule.

4. The Project Schedule shall include all the quality and critical hold points required for the inspection of the Vehicle installations.

5. During installation Contractor shall maintain the Project Schedule and SFMTA's Vehicle Installer shall update the Project Schedule weekly to provide actual and forecast dates and duration for Installation Activities.

6. Contractor shall develop a Vehicle Installation Plan [CDRL] that:

    a. Lists the Materials required to be installed, including Shop Materials. Shop Materials shall be presented separately from Contractor-provided Materials.

    b. Lists the Drawings and design documents to be used as reference to the installation

    c. Lists all detail installation Drawings and plans required by the Vehicle Installer

    d. Lists all anticipated Special Tools or equipment anticipated to be used by the Installer. This list shall include vendor, calibration, or other details.

    e. Develops the Hazard list for any Equipment to be installed.

    f. Lists and describe Inspection and Testing Requirements that Vehicle Installer must perform. Contractor shall specify all testing to be performed including which tests are performed by Contractor and which tests are performed by SFMTA Installer.

    g. Lists all SFMTA Furnished Items (see Section 9) to be modified by the Vehicle Installer.

    h. Includes a schedule for installation which accounts for SFMTA operational requirements and Vehicle availability.

    i. Describes how the Contractor inspection process verifies Vehicle Installation complies with the approved designs.

7. Contractor shall notify SFMTA if there are major discrepancies in the installation that prevent a vehicle from using the CBTC System in Revenue Service within the time specified in Section 10.2.2 of the approved Project Management Plan.

8. Within the time specified in Section 10.2.2. of the approved Project Management Plan, Contractor shall either:

    a. Confirm to SFMTA that all installation work was done properly and in accordance with approved designs and Contractor's specifications, or

    b. Submit a complete list ("Vehicle Punch List") of items that need to be remedied to achieve Acceptance for that Vehicle.

9. Following SFMTA Acceptance of all Vehicles in Revenue Service, Contractor shall be accountable to SFMTA for ensuring the System Reliability, Availability, and Maintainability Performance Targets of the CBTC System are achievable using the installed works.

10. Contractor shall not be accountable for failures resulting from items it identifies in Vehicle Punch Lists, unless those items have been remedied prior to the failure.

11. If Contractor issues a Vehicle Punch List, and SFMTA or its Installers perform rework to address the items in the Vehicle Punch List Contractor shall perform any applicable retests to confirm the items on the Vehicle Punch List have been remedied.

12. Following its performance of applicable retests, Contractor shall either:

    a. Confirm to SFMTA that all installation work was done properly and in accordance with approved designs and Contractor's specifications, or

    b. Submit another Vehicle Punch List as described in this Section.

13. Contractor shall furnish at least three separate sets of Vehicle Installation Procedures [CDRL] for LRV4, Heritage Vehicles, and Maintenance Vehicles. As each installation may be different due to the unique physical layout of each Heritage or Maintenance Vehicle, the exact number of procedure sets shall be determined based on the number of types of kits SFMTA has elected to purchase based on the Options exercised at PDR.

14. The Vehicle Installation Procedures shall be detailed and complete enough to allow the Installer to complete the CBTC equipment installation without needing to reference other documentation, other than Vehicle-specific documentation such as Vehicle manuals.

15. Contractor shall combine third-party installation instructions for any COTS components into its Vehicle Installation Procedures such that the Vehicle Installation Procedures is a complete document.

16. Vehicle Installation Procedures shall include, at a minimum:

    a. Equipment placement space, ventilation, ergonomic guidance, aesthetics, and clearance requirements

    b. Equipment mounting instructions including mounting of brackets and all required fastening hardware

    c. Mounting instructions for control panels and details of all required connections to existing control panels or operator displays.

    d. Power Supply requirements and wiring type, jacket, gauge, and connection type specifications.

    e. Specifications for grounding, bonding, and shielding facilities including bus bar hardware, wiring connections, etc.

    f. Installation instructions for any prefabricated cable harnesses/assemblies.

    g. Signal Cable and connector type specifications and fabrication instructions.

    h. Cable routing and protection specifications, and wiring diagrams showing connections

    i. Interior and exterior environmental protection specifications, including details of any enclosures, penetrations, seals, etc.

    j. Any specific instruction methods or procedures necessary to maintain eligibility for warranty, either Contractor's warranty or 3rd party COTS component warranties.

    k. Safety procedures and protocols for working with onboard Equipment installation.

8.6 DEPLOYMENT AND MIGRATION CDRLS

Table 8-11: Deployment and Migration CDRL Table

CDRL #	CDRL Title
08.01	Deployment and Migration Plan
08.02	Site – Specific Work Plans
08.03	Construction Safety Program Plan
08.04	Wayside Installation Plan
08.05	Vehicle Installation Plan
08.06	Vehicle Installation Interface List

9 SFMTA FURNISHED ITEMS

9.1 PURPOSE

1. This Section identifies and describes SFMTA Furnished Items Contractor may use to enable and facilitate the delivery of the CBTC System during the Procurement Phase. SFMTA Furnished Items may include tangible physical assets, services, easements, access windows, and other tangible and intangible resources. SFMTA Furnished Items are categorized by whether or not they are available for permanent use as an integral part of the CBTC System.

9.2 SFMTA FURNISHED ITEMS REQUIREMENTS

1. Contractor shall utilize existing SFMTA infrastructure in the design as much as possible (for example existing fiber connections, data centers, relay rooms, and wayside System control cabinets), unless these Contract Specifications state such infrastructure shall not be used.

2. Contractor shall provide a list of available SFMTA infrastructure that will not be used for SFMTA approval during Preliminary Design Review. For each item on this list, Contractor shall describe:

    a. Any cost savings that are to be gained from not using SFMTA infrastructure

    b. Any reliability improvements that are to be gained from not using SFMTA infrastructure

    c. Any other design benefits that are to be gained from not using SFMTA infrastructure

3. SFMTA Furnished Items are provided "as-is". The incorporation of SFMTA Furnished Items into the System does not relieve the Contractor of meeting the performance targets Contractor has committed to in Appendix J to the Agreement, even if the SFMTA Furnished Items are negatively impacting System performance. Contractor shall assume the responsibility for evaluating the condition of SFMTA Furnished Items and their suitability for inclusion in the design, and Contractor may choose to replace SFMTA Furnished Items with its own Equipment to ensure performance.

4. At many surface Interlockings, SFMTA uses track circuits for train detection, but SFMTA does not consider these devices reliable enough to be used as a part of the CBTC System. Contractor shall not reuse existing track circuits or incorporate track circuits in its design.

5. Contractor shall identify gaps in existing SFMTA infrastructure that are essential to its design in its Preliminary Design Review. SFMTA will either commit to providing this infrastructure or work with Contractor to modify its design.

6. The City will furnish all fiber-optic cabling and underground conduit needed for the Project. SFMTA will supply the Contractor with a citywide schematic showing the locations of all existing and available fiber-optic cable and fiber connections (“Fiber Map”). The Contractor shall annotate the Fiber Map with the connections necessary to support its design.

7. Contractor may request additional SFMTA Furnished Items not identified explicitly herein. In this case, Contractor shall establish a reasonable business case and reach mutually agreeable terms of use with SFMTA. Contractor's business case for use of additional items not explicitly identified shall include equitable Contract value adjustment.

8. Contractor shall develop and submit a SFMTA Furnished Items Plan [CDRL] for approval which:

a. Identifies and describes the use of all anticipated Furnished Items required by Contractor to execute and deliver the Project scope.

b. Details the quantity and use of any resources and anticipated schedule of required use of such resources.

c. Establishes a mutually agreeable plan for use of the items. Contractor shall describe the purpose, method, timing, planned modifications, and final disposition of SFMTA Furnished Items to be used.

d. States the Contractor's assessment of the condition of the SFMTA Furnished Items and Contractor's assumption of the expected useful life of the SFMTA Furnished Items given that assessment. If the expected useful life of the SFMTA Furnished Items is less than the expected useful life of the System, Contractor shall include a recommended replacement plan for these items.

e. Describes the handover criteria. Contractor shall detail all activities necessary to protect and ensure compliance to all safety, security (cyber or physical), access, and operational requirements of SFMTA.

f. Describes advance approval and coordination process for all Furnished Items identified.

g. Includes the expected modifications and test criteria, in case SFMTA Furnished Items are required to be modified for the purposes of the Contract, and the physical modification is not the responsibility of Contractor. This shall include additional raceway and/or conduits required to prevent over packed existing SFMTA Furnished Items.

h. Describes compliance with all safety, both physical and cyber-security, access, and other additional requirements directed by SFMTA in the use of SFMTA Furnished Items.

9.3 PERMANENT SFMTA FURNISHED ITEMS

1. Permanent SFMTA Furnished items are systems, tools, equipment, physical or cyber infrastructure, or any other SFMTA owned or used property that will be modified and not returned to their original state. SFMTA anticipates the following items will be required and be made available for Contractor's use as permanent integral parts of the CBTC System design:

    a. Light rail Vehicles, heritage fleet Vehicles, hi-rail Maintenance Vehicles, and onboard equipment.

    b. Signaling and other wayside/trackway equipment, such as switch machines, signals and road traffic signals, except for Interlockings.

    c. Communications network infrastructure (see Section 26 for details).

    d. Test tracks at Muni Metro East and Green yards, including sheds for any equipment.

    e. Facilities, including dedicated equipment rooms, data centers, workstations/equipment in shared rooms, and the subways.

    f. A licensed 40 MHz band of RF spectrum for use as a single 40 MHz channel or two 20 MHz channels, with the specific frequencies to be agreed upon by the Parties.

    g. Data management, security, and recovery IT software and services from Rubrik, Inc.

9.4 TEMPORARY SFMTA FURNISHED ITEMS

1. Temporary SFMTA Furnished Items are resources, systems, tool, equipment, physical or Software infrastructure, or any other SFMTA owned or used property that will be modified and returned to their original state. SFMTA anticipates the following items will be required and can be made available for Contractor's temporary use in deploying the CBTC System:

    a. All permits necessary for survey, installation, testing or construction work

    b. Security/law-enforcement services associated with temporary street crossing Closures

    c. Engagement of the Independent Safety Assessor, if needed

    d. All installation work: control centers, facilities, network Equipment, wayside, LRV4

    e. Maintenance activities, including the replacement of Equipment

    f. Track access

    g. Flaggers and Employees-In-Charge for field activities and testing

    h. Train Operator services

    i. Inspectors

    j. Shop personnel

    k. Trainers

    l. Maintenance shop / Pit space

    m. Operations Controllers

    n. Maintenance personnel and inspectors

    o. Facilities

    p. Coordination activities with any required third parties and stakeholders for installation, testing, and construction work

2. SFMTA will provide Contractor with office space at the Transportation Management Center facility at 1455 Market Street, San Francisco, CA 94103. This space will:

    a. Have sufficient desks for up to 20 of Contractor's staff (including the 3 private offices).

    b. Have up to 3 private offices for Contractor's use.

    c. Have at least two conference rooms available for shared use between SFMTA and Contractor.

    d. Have networking capabilities capable of reaching the Internet.

    e. Have a shared breakroom with water and basic kitchen appliances.

Table 9-12: SFMTA Furnished Items CDRL Table

CDRL #	CDRL Title
09.1	SFMTA Furnished Items Plan

10 OPERATIONS AND MAINTENANCE

10.1 PURPOSE

1. This Section specifies the requirements to assess, plan, document and optimize effectiveness of operations and maintenance activities that will be undertaken by SFMTA and Contractor after each Deployment Phase has been Commissioned.

2. This Section outlines requirements for technical support, operation, and maintenance manuals (O&M manuals), tracking data, and consolidated lists of Special Tools and testing and diagnostic equipment necessary to support System Operations and Maintenance.

3. Contractor shall use and maintain the Deliverables described in this Section during the Support Term. SFMTA staff will use Deliverables described in this Section during the Support Term.

10.2 OPERATIONS AND MAINTENANCE INTEGRATION

1. Contractor shall conduct a review of SFMTA's operations and maintenance practices to enable Contractor to become familiar with SFMTA operations and obtain SFMTA-specific information.

2. The review shall include:

   a. SFMTA's rail operating divisions and maintenance facilities;

   b. Equipment and methodologies used in SFMTA operations and maintenance;

   c. SFMTA operating and maintenance rules, procedures, and training records;

   d. Interviews of selected SFMTA operations and maintenance personnel

3. Based on the information obtained during this review, Contractor shall integrate its standard System operations and maintenance manuals, policies and procedures with SFMTA's existing operations and maintenance practices, policies and procedures.

4. Contractor shall, in consultation with SFMTA, provide recommended edits to update SFMTA operations and maintenance practices, policies and procedures to incorporate the CBTC System functionality and leverage the CBTC System's capabilities to improve system safety, incorporate best practices from Contractor's experience with its other customers, and automate as many procedures as are feasible.

5. Contractor shall develop any temporary operations and maintenance procedures that are to be used during the Deployment Phases to facilitate operations and maintenance while portions of the CBTC are operational, and submit these procedures to SFMTA for review and approval.

10.3 EXISTING SFMTA TECHNICAL PUBLICATIONS

1. Contractor shall review existing SFMTA technical publications and their usage.

2. Contractor shall recommend changes to any relevant SFMTA documentation to incorporate the capabilities of the CBTC System into them, including identifying methodology to modify any existing publications.

3. All Contractor proposed changes to SFMTA technical publications that reflect modifications due to the CBTC System, as a minimum shall include:

a. new information,

b. revisions,

c. obsolescence identification,

d. removal and replacement of selective pages or portions of documents, and

e. correction to existing SFMTA documentation.

4. Contractor shall ensure that all proposed changes to existing SFMTA technical publications that are required by the CBTC System conform to the requirements of this Section.

5. Contractor shall submit all proposed changes to existing SFMTA technical publications to the appropriate change review process, as described in Section 15.

10.4 Operating Scenarios and Operating Procedures

1. Contractor shall submit an Updated Operating Scenarios document [CDRL] that describes all operating scenarios supported by Contractor's CBTC System functionality.

2. Contractor shall use SFMTA current procedures as a basis to provide both an understanding of new and existing scenarios.

3. Operating scenarios shall describe SFMTA and CBTC System's interaction for the normal and abnormal operating scenarios described in the Concept of Operations and Maintenance.

4. Upon SFMTA approval, Contractor shall use the Updated Operating Scenarios document as the basis for recommending new Standard Operating Procedures [CDRL] for SFMTA approval.

5. Contractor shall develop and provide Standard Operating Procedures (SOPs) that provide procedures to be followed by SFMTA operations staff to address any operating scenario in the Updated Operating Scenarios document.

6. Contractor shall submit new SOPs and provide recommended edits to existing SFMTA SOPs based on the Updated Operating Scenarios document.

7. Contractor shall submit specific Safety Standard Operating Procedures related to specified system safety designs and the sequence and precedence of their use, e.g., procedures on the Use of Safety Devices or Use of Warning Devices respectively.

10.5 Maintenance Plan

1. Contractor shall submit a Maintenance Plan [CDRL], which describes all preventive, diagnostic, and corrective maintenance activities, and defines the maintenance environment recommended for all CBTC System Equipment, including TMC, OCC, CBTC Training Facility, wayside Equipment, Back-end Infrastructure (including network), and Vehicle Equipment that supports Contractor's Reliability and maintenance requirements.

2. The Maintenance Plan shall include, at a minimum, the following:

a. Any recommended maintenance approaches that may affect SFMTA staffing levels or organizational structure must be clearly identified as proposed and require SFMTA approval.

b. Recommended staffing levels, maintenance personnel, qualification requirements, and other required SFMTA resources

c. List and description of all Line Replaceable Units (LRU) and Lowest Line Replaceable Unit (LLRU)

d. A summary and reference to all test/diagnosis, repair procedures, System recommissioning requirements and descriptions

e. List and description of all required operation and maintenance manuals and recommended additions [CDRL]

f. Identify all SFMTA documents that require modification and submit this listing to SFMTA for review and approval

g. Preventive maintenance and Corrective maintenance procedure descriptions and references per the Reliability, Availability and Maintainability (RAM) requirements of Section 30, including schedule, instructions, tools and required labor, Materials, and consumables.

h. Recommended Preventive Maintenance and Equipment certification frequencies for all Equipment.

i. Predicted annual person-hours for each preventive and corrective maintenance activity (as per RAM requirements stated in Section 30).

j. Delivery and management of Special Tools, simulator(s), diagnostic and test equipment, and spare parts. Details must include calibration requirements of all tools and special storage and any periodic inspection/testing required for spare part held in stores.

k. Process and procedures for Back-end infrastructure maintenance, Software patch and Software release procedures and Preventive Maintenance for these systems.

10.6 OPERATION AND MAINTENANCE (O&M) MANUALS

10.6.1 GENERAL

1. Contractor shall review existing SFMTA operating rules, regulations, procedures, and bulletins prior to developing O&M manuals.

2. Contractor shall recommend edits to existing SFMTA operating rules, regulations, procedures, and bulletins necessary to ensure technical accuracy with respect to the CBTC System. SFMTA will review the recommended edits and modify its operating rules, regulations procedures and bulletins as necessary.

3. Contractor shall provide O&M manuals that are consistent with SFMTA's operating rules, regulations, procedures, and bulletins.

4. Contractor shall develop and submit temporary Operating Rules and Procedures, O&M manuals, and/or Operating Bulletins that are unique to the Deployment Phases or Migration state for any unique operational and maintenance procedures governing the CBTC System during Deployment Phases or Migration [CDRL].

5. Contractor shall submit these temporary Operating Rules and Procedures, O&M manuals, and/or Operating Bulletins during each Deployment Phase or Migration state in addition to the required

operating rules and procedures, O&M manuals, and/or operating bulletins submitted at full Deployment.

6. Contractor shall expand on the descriptions contained in SFMTA accepted Maintenance Plan and provide O&M manuals for all Equipment including assemblies, sub-assemblies, components, and systems furnished under this Contract that requires maintenance, operation, or modification.

7. O&M manuals shall serve the purposes of supporting training, simulation and testing in addition to being a reference for operations and maintenance procedures.

8. The contents of each O&M manual shall serve as the basis for training course materials and shall be completed prior to start of training course delivery.

9. O&M Manuals shall be delivered for use in the Training Program and updated as necessary prior to any Phase handover to SFMTA Operations and separate Operations and Maintenance Contractor.

10. Contractor shall develop and submit all required manuals in accordance with the following:

    a. All O&M manuals shall be prepared in English for all CBTC Equipment and Software furnished under this Contract.

    b. All O&M manuals shall include lists and descriptions of safety warnings and methods of protection and mitigation (e.g., electrostatic discharge).

    c. All general submittals except for required manuals shall be submitted electronically.

    d. All electronic submittals shall include files created from Adobe Acrobat, (latest release in use by SFMTA) and native files (e.g., MS Word, MS Excel, AutoCAD).

    e. Contractor shall submit three hard copies of all required manuals with a new set of three hard copies for each revision for each SFMTA Facility [CDRL].

    f. All SFMTA accepted O&M manuals will be placed in SFMTA's technical libraries and documentation archive for SFMTA use.

11. Contractor shall migrate content from the COTS O&M manuals into the CBTC System O&M manuals as necessary, such that the CBTC System O&M manuals are the only source of information needed to operate and maintain the CBTC System.

12. If Contractor has standard product manuals which meet the requirements of more than one manual listed as a CDRL in these Contract Specifications, Contractor may use a single manual in place of the CDRLs, reducing the overall number of manuals Contractor must provide. Contractor shall request SFMTA approval to combine multiple CDRLs in this way prior to delivering the single manual.

13. Contractor shall include in its request to combine CDRLs into a single manual a justification demonstrating how all the requirements of the CDRLs it replaces are met with the single manual.

10.6.2 MANUAL TYPES

1. Contractor shall familiarize itself with the roles and responsibilities of each SFMTA personnel classification who will operate and/or maintain subsystems.

2. Through collaborative workshops and input from SFMTA end users of the CBTC System O&M manuals, Contractor shall develop and submit each O&M manual tailored specifically to SFMTA personnel.

3. Operations manuals shall be organized by job function/role (i.e. Transportation Controllers, Train Operators, etc.).

4. Maintenance manuals shall be organized by subsystems or components.

10.6.3 CBTC SYSTEM DESCRIPTION MANUAL

1. Contractor shall develop and submit a CBTC System Description Manual [CDRL] that contains general information on the CBTC System, main components (and interfaces between them), as well as the principle of operation of the System and its components.

2. The CBTC System Description Manual shall be written such that SFMTA personnel at all levels and departments can comprehend the information provided.

3. The content of the CBTC System Description Manual shall serve as reference material for all training courses.

4. An overview of the System architecture including the organization of subsystems shall be included in the CBTC System Description Manual.

5. The CBTC System Description Manual shall include a section describing the organization of all other CBTC O&M manuals.

10.6.4 CBTC OPERATIONS AND SAFETY MANUAL

1. Contractor shall develop and submit a CBTC Operations and Safety Manual [CDRL] consistent with current SFMTA policies and procedures included in Appendix J to the Agreement.

2. The CBTC Operations and Safety Manual shall contain all information necessary for SFMTA Transit Division staff to operate and support the CBTC System including but not limited to the following:

    a. All information needed for the optimal safe operation of the CBTC System

    b. General CBTC System familiarization material, such as:

        i. Location, function and operation of SFMTA-personnel applicable controls, gauges, indicators, and switches

        ii. System overview (basic description of the CBTC System and Hardware, with layout diagrams and introduction of CBTC System functions)

    c. Normal operating procedures

    d. Failure recovery procedures (i.e., resets and bypass functions)

    e. Failure mode operating procedures

    f. CBTC user interface description specific to SFMTA personnel who will be using the device (i.e., Train Operator’s Display, ATS Display)

2. As part of the development of the CBTC Operation and Safety Manual, Contractor shall reference, review, and propose changes to the following documentation, at minimum, such that SFMTA, in turn, is able to update:

    a. Train Operator's Manual

    b. Transportation Controller's Manual

    c. (Yard) Foreman Manual

10.6.4.1 ATS OPERATIONS MANUAL

1. Contractor shall develop and submit an ATS Operations Manual [CDRL] which provides a detailed understanding of how the CBTC System operates and functions and how information (including component and subsystem failures) is displayed on ATS Equipment.

2. The ATS Operations Manual shall be developed for the Transit Division Transportation Management Center (TMC) staff.

3. The ATS Operations Manual shall include the following information, at minimum:

    a. Details of the operation and use of the local and remote diagnostic functions of the CBTC System

    b. Service plan and operating schedules implementation

    c. Transfer of control between operation control facilities

    d. User guidance and error messages, along with the steps necessary to recover from errors

    e. Illustration of each type of user display used in the CBTC System, along with a description of each dynamic data field

    f. User instructions for all interactive procedures associated with the data fields on each display associated with the System functions

    g. Special operations and use of Equipment at specific locations

    h. Procedures for Playback and simulation.

10.6.4.2 INSTALLATION, REPAIR, AND MAINTENANCE MANUALS

1. Contractor shall develop and submit CBTC installation, repair, testing and maintenance manuals that provide information and procedures needed for SFMTA maintenance personnel to perform Equipment installations, routine inspections, scheduled servicing and Preventive Maintenance and adjustments, on-line trouble diagnosis of each element of System, troubleshooting guides, corrective maintenance, Equipment specifications, and schematics for the Vehicle and wayside CBTC Equipment and systems, including Equipment installed on Heritage and Maintenance Vehicles.

2. Contractor shall submit CBTC maintenance manuals including, but not limited to the following:

    a. Wayside CBTC Installation, Repair, and Maintenance Manual [CDRL]

    b. Onboard CBTC Installation, Repair, and Maintenance Manual [CDRL]

    c. Data Communications Subsystem Installation, Repair, and Maintenance O&M Manual [CDRL]

d. Central CBTC Installation, Repair and Maintenance Manual [CDRL]

3. Contractor shall include technical descriptions and theories of operation for the CBTC System and relative major subsystem components in each maintenance manual.

    a. The Wayside CBTC Installation, Repair, and Maintenance Manual shall include all information necessary for SFMTA personnel to perform wayside inspection and servicing activities (e.g., database of location and tolerances for wayside CBTC Equipment).

    b. The onboard CBTC Installation, Repair, and Maintenance Manuals shall include information for retrofitting on-board Equipment on each Vehicle while keeping consistent with existing O&M manuals.

    c. The Data Communications Subsystem Installation, Repair, and Maintenance O&M Manuals shall include information for installing, configuring, and maintaining Data Communication System components.

    d. The Central CBTC System Installation, Repair, and Maintenance O&M Manual shall include information for installing, configuring, and maintaining the central (including ATS, AMS) System components.

4. Each installation, repair, and maintenance manual shall include the following, at a minimum:

    a. Description of each subsystem, operating modes and setup, Equipment start-up and shutdown, control and monitoring functions, physical arrangement, and typical operating characteristics;

    b. Description of each procedure step, detailing the purpose, location, tools, and supplies required, measurement settings and minimum tolerances, condemning values, instrumentation adjustments, and suitable diagrams and/or photographs;

    c. Recommended frequencies of periodic certification inspection/maintenance procedures for all elements of the CBTC System, as well as calendar Day inspection procedures for all inspections;

    d. Identification of safety Hazards and handling procedures associated with the Equipment or maintenance procedures as warnings and cautions;

    e. Basic schematic and block diagrams to provide fault diagnostic information necessary for in-service maintenance;

    f. Installation, removal, and replacement procedures for each Line Replaceable Unit (LRU), with lead times for factory restoration or repair (that is, mean times to restore/repair);

    g. Standard messages and screenshots;

    h. Instructions for use of test equipment for repair/replacement, adjustment, test, and troubleshooting functions;

    i. Logical sequence of testing and other application procedures to allow the end user to identify and locate the defective component;

    j. Testing requirements to return the repaired or replaced unit back into service;

    k. Early warning detection of Equipment problems and recommended measures for resolving problems

10.6.4.3 ATS SUBSYSTEM ADMINISTRATION MANUALS

1. Contractor shall develop and submit an ATS Subsystem Administrator Manual [CDRL] consisting of ATS subsystem and network equipment function, operation, and Configuration.

2. The ATS Subsystem Administrator Manual shall describe, at minimum, the following:

    a. Server back-up operation and monitoring

    b. User instructions for administration, installation and maintenance of servers

    c. All aspects of Software administration

    d. Maintenance of network security

    e. Testing of new Software releases and application updates

    f. Definition, control, and assignment of user access to all console systems including, but not limited to, Train Operator's Displays, OCC, CBTC Training Facility, simulators, test equipment

    g. Location and scaling of all adjustment parameters clearly explained to System maintenance personnel using the System interface to make Software parameter adjustments.

10.6.4.4 SIMULATOR OPERATION MANUALS

1. Contractor shall develop and submit a CBTC System Simulator Operation Manuals [CDRL] for each CBTC System simulator describing its operational use.

2. CBTC simulators and supporting documentation are required for training SFMTA personnel on the application and testing of Operations Control Center (OCC), Transportation Management Center (TMC), wayside, and Vehicle onboard Equipment.

3. Simulator Operation Manuals shall comply with the requirements described in Section 21 (Simulators and Tools) of these Specifications.

4. Simulator Operation Manuals shall include detailed examples of user-definable functions and parameters which specifically address common needs of SFMTA trainers and trainees.

10.6.4.5 SIMULATOR MAINTENANCE MANUALS

1. Contractor shall develop and submit CBTC Simulator Maintenance Manuals [CDRL] for each CBTC System simulator describing procedures for maintenance, adjustment, inspection, troubleshoot, repair, and replacement of simulator Equipment.

2. Each CBTC Simulator Maintenance Manual shall include the following, at minimum:

    a. Description of each major unit, operating modes and setup, Equipment start-up and shutdown, control and monitoring functions, physical arrangement, and typical operating characteristics shall be provided.

    b. Recommended frequencies and periodic inspection/maintenance procedures for all tasks, as well as calendar day inspection procedures for all inspections

    c. Basic schematic and block diagrams to provide fault diagnostic information appropriate for in-service maintenance

d. Installation, removal, and replacement procedures for each major component

e. List and description of standard messages and screenshots

f. Software and Hardware parameter adjustments and application updates

10.6.4.6 SOFTWARE USER MANUALS

1. Contractor shall develop and submit Software User Manuals [CDRL] for maintenance containing detailed operating instructions and procedures for SFMTA end users to configure, operate, load, uninstall, run new executables, and test Software for each microprocessor subsystem supplied.

2. The Software User Manuals shall include descriptive procedures to be followed in using the Software functionality, maintenance, troubleshooting diagnostics and uploading revisions for Vehicle onboard, wayside, Back-end Infrastructure, network and TMC Software with version control and its management by the System.

3. The Software User Manual contents shall be based upon a standard system of organization and presentation.

4. The Software User Manuals shall include detailed descriptions of the following, at a minimum:

    a. System operation as it relates to the user's tasks

    b. Function and use of each application program with explanations of how each step is performed, its function, what parameters can be adjusted, the effects obtained by varying each parameter, and potential errors and results that occur when the parameter is varied. Specifically, all parameter adjustments that can result in safety System adjustments shall be well marked and highlighted.

    c. User guidance and error messages, along with steps necessary for recovery from the error.

    d. Procedures for routine maintenance, recovery from System failures, and response to computer System restarts/failures/failovers

    e. System notifications and alarm conditions

10.6.5 REVISIONS

1. During the entire Contract Term, Contractor shall submit revisions, updates, and alterations to approved O&M manuals when any element of the CBTC System is changed so that the O&M manuals always describe the current CBTC System and each of its elements that is in service.

2. Updates or revisions to text and illustrations in O&M manuals shall meet the following requirements:

    a. Ensure that all applicable Contractor furnished O&M manuals are updated to reflect the change(s) via page change-outs for hardcopies and new edited files for electronic formats.

    b. Provide a List of Changed Pages to be issued with each review submittal and revision of the O&M manuals.

    c. Provide and update at the beginning of each O&M manual, a Configuration Control Record form in the format provided by SFMTA. The form shall include columns for the chapter, page number, change order number, revision number, revision date, and revision description.

d. New or modified content shall be indicated in the manual with a vertical line in the outside margin alongside any new or modified text, tables, or images.

10.6.6 FORMATS

1. Contractor shall propose their overall manual delivery format and methodology based upon Contractor's best practice and in support of Reliability and Availability requirements. SFMTA will review the proposed format.

2. Contractor shall obtain SFMTA's approval before publishing manuals.

10.6.6.1 POSTED INSTRUCTION MANUALS

1. For each location where CBTC Equipment is installed, except onboard Vehicles, Contractor shall submit a single set of printed sheets under framed clear acrylic plastic that offer brief, concise operating and maintenance instructions for each subsystem or assembly of the CBTC present at that location that the SFMTA will maintain, remove or install.

2. Each posted instruction shall be referenced in the O&M Manuals.

10.6.6.2 COMMERCIAL OFF-THE-SHELF EQUIPMENT MANUALS

1. Contractor shall supply commercial off-the-shelf (COTS) manuals for Equipment sub-assemblies and components which contain the manufacturer's operating instructions and other operation and maintenance information available from the manufacturer without need for modifications, Drawings, or manual revisions.

2. Contractor shall submit these manuals to SFMTA prior to initial delivery of the Equipment.

10.7 ASSET MANAGEMENT

1. SFMTA manages Equipment and maintenance data through its Enterprise Asset Management System (EAMS). Contractor shall support SFMTA's management and data entry into the EAMS by identifying O&M manual procedures corresponding to CBTC assets, Configuration, location, and parts data.

2. Contractor shall review and submit extracted excerpts of approved O&M manuals, and submit that information in an electronic format compatible with EAMS.

10.8 OPERATIONS AND MAINTENANCE CDRLS

Table 10-13: Operations and Maintenance CDRL Table

CDRL #	CDRL Title
10.01	Updated Operating Scenarios
10.02	Operating Procedures
10.03	Maintenance Plan
10.04	List and description of all required operation and maintenance manuals and recommended additions
10.05	Updated operating rules and procedures, O&M manuals, and/or operating bulletins during Migration

CDRL #	CDRL Title
10.06	Complete set of pertinent hardcopy manuals for each SFMTA facility
10.07	CBTC System Description Manual
10.08	CBTC Operation and Safety Manual
10.09	ATS Operations Manual
10.10	Wayside CBTC Installation, Repair, and Maintenance Manual
10.11	Onboard CBTC Installation, Repair, and Maintenance Manual
10.12	Data Communications Subsystem Installation, Repair, and Maintenance O&M Manual
10.13	Central CBTC Installation, Repair, and Maintenance O&M Manual
10.14	ATS System Administrator Manual
10.15	CBTC System Simulator Operation Manuals
10.16	CBTC Simulator Maintenance Manuals
10.17	Software User Manuals

11 TRAINING

11.1 PURPOSE

1. The purpose of this Section is to describe Contractor requirements to develop and provide necessary training and operational support to SFMTA personnel, and to describe requirements of the operations and maintenance training program.

2. Contractor shall provide general training to SFMTA operations and maintenance personnel that covers the entire System and Contractor shall provide specific role-based training focused on the elements of the System for which trainees are responsible. Contractor's training plan shall include updates and refresher courses to keep current with System changes and developments during the Contract Term.

11.2 TRAINING PROGRAM

1. Contractor shall develop a comprehensive Training Program Plan [CDRL] that meets the goals and objectives of the operations and maintenance training program.

2. Contractor shall consult with SFMTA operations and maintenance personnel to develop a training program that addresses Hardware, Software, interfaces, installation, network issues and ensures that SFMTA existing operational and maintenance processes and expectations are considered.

3. The Training Program Plan shall describe:

    a. The training required for each level of maintenance and the tools, processes, equipment, and staffing required for each level.

    b. Training required to maintain the System with RAM requirements including any training demonstrations that may be used to support Mean Time to Repair (MTTR) targets.

    c. SFMTA and Contractor's respective roles and responsibilities for each training activity for each level of maintenance.

    d. The processes used to develop training courses, including needs assessment, design plans, and field trials.

    e. The seven training courses listed in this Section 11.2. Course descriptions shall include lesson plans, job classification(s) and role(s) of personnel required to attend, frequency of training, proficiency required to obtain certification or qualification, including evaluation methods and standards, and methods for addressing failures or retraining.

    f. The lessons comprising each training course. The description for each lesson shall at least include the lesson title, lesson objectives, topics covered, type of lesson (e.g., "online," "hands-on," "CBT", etc.) and materials used.

    g. Separate curricula for new hire training and refresher training for each training course, including a list of the lessons included in each.

    h. All supporting documentation, training materials, training tools, required temporary or permanent training equipment needed for the Training Program.

    i. How instructor-led lessons (both virtual and in-person) and interactive computer-based training will be used in training SFMTA personnel.

j. A schedule of all training courses (and locations) to be held from NTP to Final Acceptance.

k. Any prerequisite training requirements (that is, training that attendees must have received before attending the training course), and certification requirements.

4. Contractor shall include descriptions for the training courses described in Sections 11.2.1 through 11.2.7 in its Training Program Plan.

5. Contractor shall provide ongoing annual refresher training for each training course as part of its Support Services starting at Final Acceptance through the Contract Term.

11.2.1 TRAIN OPERATOR COURSE

1. Contractor shall develop a Train Operator training course for SFMTA instructors to deliver to all Train Operators covering safe and effective use and operation of the CBTC System.

2. Contractor shall provide training materials for the Train Operator training course as described in Section 11.3 (Training Materials).

3. Contractor shall train SFMTA trainers to deliver the Train Operator training course as described in Section 11.2.7 (Instructor Training Courses).

4. The Train Operator training course shall include classroom and simulator hours along with mainline and yard operations.

5. The Contractor shall develop a proficiency test for Train Operators to demonstrate their knowledge of the CBTC System at the conclusion of the Train Operator training course.

6. The Train Operator training course shall cover at least these topics:

   a. Rule Book and Standard Operating Procedure updates relevant to the CBTC System

   b. Vehicle operations, including modes of operation

   c. Vehicle troubleshooting and error messages

   d. Fault recovery management

   e. Contingency operations

   f. Emergency procedures

   g. Non-Communicating Train operating procedures

11.2.2 OPERATIONS MANAGEMENT COURSE

1. Operations Managers will attend a portion of the Transportation Controller course described in 11.2.3. The Contractor shall group the training topics in the Transportation Controller course designated by SFMTA as applicable to Operations Managers together in the course schedule so that Operations Managers may attend at the same time.

2. Contractor shall provide an introductory lesson for Operations Managers covering the analytics and reports provided by the CBTC System.

11.2.3 TRANSPORTATION CONTROLLER COURSE

1. Contractor shall develop a Transportation Controller training course and provide the course to all Transportation Controllers on safe and effective use and operation of the CBTC System.

2. For each session described in Section 11.4 and each annual refresher training session, Contractor shall train a minimum of 4 Transportation Controller classes.

3. The maximum class size of the Transportation Controller training course shall not exceed 10 students.

4. The Transportation Controller training course shall include classroom and simulator hours.

5. Contractor shall develop scenarios to load into the ATS simulator for trainee instruction and evaluation as part of the Transportation Controller training course.

6. The Contractor shall develop a written proficiency test and a practical examination on the ATS simulator, which will require the Controller to demonstrate their knowledge of the CBTC System at the conclusion of the Transportation Controller training course.

7. The Transportation Controller training course shall cover at least these topics:

    a. Principles of the operation of the CBTC

    b. System overview, including System architecture, subsystems, their function and location

    c. Rule Book and Standard Operating Procedure updates relevant to the CBTC System

    d. ATS operation, including the GUI and ATS controls

    e. ATO and ATP functions

    f. Vehicle operations

    g. System messages and alarms

    h. Service management techniques and procedures

    i. Failure management and wayside maintenance dispatch

    j. Vehicle troubleshooting and Vehicle maintenance dispatch

    k. Contingency operations

    l. Non-Communicating Train operating procedures

    m. Central Equipment failure procedures, including System restart and transferring System functions to the secondary Central Equipment on cold standby

    n. Emergency procedures

    o. System recovery

    p. Issue reports and procedures for requesting Contractor Warranty or Support Services

11.2.4 VEHICLE MAINTENANCE COURSE

1. Contractor shall develop a Vehicle Maintenance training course and provide the course to all Vehicle maintenance staff on safe and effective maintenance of the CBTC System.

2. For each session described in Section 11.4 and each annual refresher training session, Contractor shall train a minimum of 3 Vehicle Maintenance classes.

3. The maximum class size for the Vehicle Maintenance training course shall not exceed 15 students.

4. The Vehicle Maintenance training course is the training for Vehicle maintenance personnel in the recommended procedures necessary to maintain the CBTC System so that it meets the Performance Requirements. Participants will be able to maintain, troubleshoot, and repair Vehicle onboard subsystems upon completion of the course.

5. The Vehicle Maintenance training course shall include lectures, demonstrations, and hands-on exercises including bench test and simulator training.

6. The Contractor shall develop a written proficiency test and a practical examination on one or more simulators used in CBTC Vehicle onboard subsystems maintenance, which will require the trainee to demonstrate their knowledge of the CBTC System at the conclusion of the Vehicle Maintenance training course.

7. The Vehicle Maintenance Training course shall cover at least these topics:

    a. CBTC System overview, including System architecture, subsystems, their function and location

    b. Vehicle subsystems

    c. System Configurations

    d. AMS, diagnostics, and System monitoring

    e. Preventative maintenance

    f. System messages and alarms

    g. Vehicle troubleshooting, error messages and fault diagnosis

    h. Field repairs and failed train procedures

    i. Corrective maintenance and repair procedures

    j. EAMS and maintenance records

    k. Issue reports and procedures for requesting Contractor Warranty or Support Services

    l. Equipment handling and obtaining spare parts from Contractor

11.2.5 WAYSIDE MAINTENANCE COURSE

1. Contractor shall develop a Wayside Maintenance training course and provide the course to all wayside maintenance staff on safe and effective maintenance of the CBTC System.

2. For each session described in Section 11.4 and each annual refresher training session, Contractor shall train a minimum of 3 Wayside Maintenance classes.

3. The maximum class size of the Wayside Maintenance training course shall not exceed 15 students.

4. The Wayside Maintenance training course is the training for wayside maintenance personnel in the recommended procedures necessary to maintain the CBTC System so that it meets the Performance

Requirements. Participants will be able to maintain, troubleshoot, and repair wayside subsystems upon completion of the course.

5. The Wayside Maintenance training course shall include lectures, demonstrations, and hands-on exercises including bench test and simulator training.

6. The Contractor shall develop a written proficiency test and a practical examination on one or more simulators used in CBTC wayside subsystems maintenance, which will require the trainee to demonstrate their knowledge of the CBTC System at the conclusion of the Wayside Maintenance training course.

7. The Wayside Maintenance Training course shall cover at least these topics:

    a. CBTC System overview, including System architecture, subsystems, their function and location

    b. Wayside subsystems

    c. Communications and network subsystems

    d. System Configurations

    e. AMS, diagnostics, and System monitoring

    f. Special Tools and Equipment needed for wayside maintenance

    g. Preventative maintenance

    h. System messages and alarms

    i. System troubleshooting, error messages and fault diagnosis

    j. Corrective maintenance and repair procedures

    k. EAMS and maintenance records

    l. Issue reports and procedures for requesting Contractor Warranty or Support Services

    m. Equipment handling and obtaining spare parts from Contractor

11.2.6 CENTRAL EQUIPMENT AND COMMUNICATIONS NETWORK MAINTENANCE COURSE

1. Contractor shall develop a Central Equipment and Communications Network (CECN) Maintenance training course and provide the course to all wayside maintenance staff on safe and effective maintenance of the CBTC System.

2. For each session described in Section 11.4 and each annual refresher training session, Contractor shall train a minimum of 1 Central Equipment and Communications Network (CECN) Maintenance class.

3. The maximum class size of the CECN Maintenance training course shall not exceed 15 students.

4. The CECN Maintenance training course is the training for Central Equipment, communications subsystem and network maintenance personnel in the recommended procedures necessary to maintain the CBTC System so that it meets the Performance Requirements. Participants will be able to maintain, troubleshoot, and repair central, communications, and network subsystems upon completion of the course.

5. The CECN Maintenance training course shall include lectures, demonstrations, and hands-on exercises including bench test and simulator training.

6. The Contractor shall develop a written proficiency test and a practical examination on one or more simulators used in CBTC central, communications, and network subsystems maintenance, which will require the trainee to demonstrate their knowledge of the CBTC System at the conclusion of the CECN Maintenance training course.

7. The CECN Maintenance Training course shall cover at least these topics:

    a. CBTC System overview, including System architecture, subsystems, their function and location

    b. Communications and network subsystems

    c. Central Equipment

    d. Wayside subsystems

    e. Simulators

    f. System Configurations

    g. AMS, diagnostics and System monitoring

    h. NMS and network monitoring

    i. Cybersecurity

    j. Interfaces with Third-Party Systems

    k. Preventative maintenance

    l. System messages and alarms

    m. System troubleshooting, error messages and fault diagnosis

    n. Central Equipment failure procedures, including System restart and transferring System functions to the secondary Central Equipment on cold standby

    o. Corrective maintenance and repair procedures

    p. EAMS and maintenance records

    q. Issue reports and procedures for requesting Contractor Warranty or Support Services

    r. Equipment handling and obtaining spare parts from Contractor

11.2.7 INSTRUCTOR TRAINING COURSES

1. Contractor shall develop Instructor Training courses to train SFMTA personnel to teach each of the five courses listed in Sections 11.2.1 through 11.2.6.

2. Instructor Training courses shall be provided to SFMTA personnel identified by the Agency as instructors.

3. For each session described in Section 11.4 and each annual refresher training session, Contractor shall train a minimum of 1 class for each of the five Instructor Training courses described in Sections 11.1 and 11.3-11.6.

4. The maximum class size of the Instructor Training course shall not exceed 5 students.

5. SFMTA may require its instructors to teach only one course or may require instructors to teach multiple courses. Contractor shall structure the Instructor Training courses to issue separate and distinct qualifications for each of the six courses.

6. The Instructor Training course shall include lectures, demonstrations, and hands-on exercises necessary to match the course curricula for which the instructors are being trained to teach.

7. The Contractor shall develop a written proficiency test and a practical examination which will require the instructor trainee to demonstrate their mastery of the course material.

8. The Instructor Training course for Train Operators shall be provided to Train Operator trainers and expert Train Operators who operate Trains during CBTC and maintenance testing.

9. The Instructor Training course for Train Operators shall cover CBTC vehicle testing procedures applicable to a Train Operator in addition to the other material described in Section 11.2.1.

10. Contractor shall design a decorative instructor badge. The badge shall be a metal lapel pin and may use color.

11. Contractor shall deliver 200 instructor badges to SFMTA before the first instructor course.

11.3 TRAINING MATERIALS

1. Contractor shall supply Interactive Training Course Materials for virtual instructor led courses and interactive computer-based training.

2. The training materials shall be organized for specific roles being trained for as detailed in a Catalogue of Training Materials [CDRL] for each training course supplied to SFMTA.

3. Contractor shall update training materials with every Software release and installation of next generation Equipment so that training materials always address the CBTC System in service.

4. Changes to text and images in the training materials are subject to SFMTA approval and shall be indicated with a vertical bar in the margin alongside the changed content.

11.3.1 CURRICULUM

1. Contractor shall submit to SFMTA a Training Curriculum Document [CDRL] describing the training courses for each personnel category (role) that will operate or maintain the CBTC System.

2. The curriculum shall include a recommended training schedule for each role, and a recommended refresher training schedule.

11.3.2 MANUALS

1. Contractor shall submit Training Manuals [CDRL] for course instructors and participants in digital format and three hard copies for each manual. Contractor shall provide a new set of three hard copies

with each revision of each training course. The training manuals shall contain text, images and diagrams as required to present clear details for the information being taught, based upon approved O&M Manuals. Hard copies shall be printed double-sided in color using letter-sized paper and delivered bound or in binders.

11.3.3 EVALUATION MATERIALS

1. Contractor shall submit evaluation materials [CDRL] such as quizzes and exams for each training course that will assess a trainee's applicable knowledge and competency.

2. A minimum passing grade shall be specified in Contractors Training Curriculum Document [CDRL] for each quiz and exam and shall be listed in the course curriculum.

3. The quizzes and exams shall be provided in digital formats.

4. Where practical examination is required, a recommended list of practical operations shall be provided, and an evaluation guide provided for the trainer to evaluate the performance of the trainee.

5. Contractor shall describe how the integrity of the evaluation process will be maintained; for example, to reduce the risk of answers being known prior to the evaluation, how will the testing material be secured and sufficiently varied to ensure the same test is not delivered to every class, but still maintain testing integrity.

11.3.4 INSTRUCTOR TRAINING MATERIALS

1. Contractor shall provide all necessary training materials for SFMTA instructors, both for instructors to use to teach their training courses and for the Instructor Training Courses.

2. Contractor shall submit all training materials for courses in both instructor and student formats.

3. Contractor shall provide all training materials identified in the Training Program Plan, to include training manuals, video recordings and interactive training tools.

11.3.5 COMPUTER BASED TRAINING

1. Contractor shall supply Computer Based Interactive course materials [CDRL] in a software format that operates on COTS computers.

2. Contractor shall submit the following Computer Based Interactive course materials:

    a. Lessons for operations courses that provide an overview of the System and its subsystems, provides step-by-step procedures to Transportation Controllers for each type of command, includes photos of the System GUI, and includes practical exercises with graphics where the trainee is asked to operate the System in typical train operations scenarios.

    b. Lessons for maintenance courses that provide an overview of the System and its subsystems, provides step-by-step procedures to technicians for each type of repair scenario, includes photos of the actual parts, and includes practical exercises with graphics where the trainee is asked to walk the System through typical repairs.

    c. Computer-Based Interactive training shall present common problems and issues that SFMTA operations and maintenance personnel regularly must resolve.

d. Computer-Based Interactive training shall use graphics and images depicting the indications present in the GUI and equipment at each step of the step-by-step procedures.

e. Computer-Based Interactive training for Transportation Controllers shall use screenshots of the Automatic Train Supervisory system.

f. Computer-Based Interactive training for maintenance personnel shall use images of the Equipment.

g. An interactive mock-up of the Asset Management System (AMS) shall be included in Computer Based Interactive training

h. Computer Based Interactive training shall include instruction and exercises designed to familiarize maintenance technicians with the features, functions, indications, alerts of the AMS.

2. The interactive training computer-based training and video recordings shall supplement and provide additional clarity to the training manuals. For maintenance training, computer-based training and video recordings shall provide a step-by-step explanation for maintenance tasks.

11.3.6 TRAINING SIMULATORS

1. Contractor shall use simulators to enhance the training effectiveness and provide more realistic training.

2. Contractor shall submit training scenarios (which are narrative, instructions for the trainer, and any scripts or Software to be loaded into the simulators) for the Automatic Train Supervision (ATS) Simulator Suite and Train Operator Training Simulator, to help familiarize the trainees with realistic CBTC usage scenarios.

3. Details of these training scenarios [CDRL] including the details of any trainee workstations and Configuration details shall be provided to SFMTA for approval.

4. The provision of Equipment for the ATS Simulator Suite shall include details for the installation, test, and Commissioning of this Simulator Suite.

5. Documentation provided with the delivery of training shall include scenario and scripts required to develop and run operational simulations.

6. Contractor shall use, for maintenance training, Second Line Maintenance Devices (SLMDs or equivalent) to provide realistic training on working with the physical devices and replacing Line Replaceable Units (LRUs).

11.4 TRAINING SCHEDULE

1. Contractor shall create a Training Schedule [CDRL] covering the Contract Term.

2. Contractor shall collaborate with SFMTA to determine the specific dates of the training courses.

3. Prior to Final Acceptance, Contractor shall conduct a minimum of three training sessions that are connected to the following three milestones: Pilot Phase Commissioning, Subway Cutover, and Final Acceptance. Contractor shall schedule sessions as close as possible to the actual dates of these milestones.

4. Training courses shall be scheduled so that SFMTA personnel receive training as needed to maintain the Project Schedule, but not so far ahead of operations that they must be retrained prior to Revenue Service.

5. The Training Schedule shall include deadlines for the delivery of training materials and a timeline for initial and refresher training courses. The SFMTA and Contractor will confer as to the size of training courses with the goal to maximize training efficiency and effectiveness.

6. To further leverage interactive training to increase efficiency, Contractor shall use the City's Learning Management System (LMS) to track training progress and schedule additional and refresher training courses for each trainee.

7. Contractor shall submit the status of the training program progress in the Monthly Project Report.

11.5 TRAINING CDRLS

Table 11-14: Training CDRLs Table

CDRL #	CDRL Title
11.01	Training Program Plan
11.02	Catalog of Training Materials
11.03	Training Curriculum Document
11.04	Training Manuals
11.05	Evaluation Materials
11.06	Computer Based Interactive Course Materials
11.07	Simulator Details
11.08	Training Schedule

12 SUSTAINABILITY

12.1 PURPOSE

1. This Section specifies the livability, environmental quality, and support of economic prosperity goals Contractor shall design, construct, and design the operation of the Communications Based Train Control (CBTC) System to maximize San Francisco Municipal Transportation Agency (SFMTA) sustainability goals.

2. As a national leader in sustainability, SFMTA continues to provide innovative, energy-efficient solutions. By increasing the capacity and reliability of the Muni system, the Project will help to reduce traffic congestion, commute times and energy consumption. The City of San Francisco adopted its Transit First Policy in 1973. The Transit First Policy includes seven integrated climate mitigation program areas. SFMTA in collaboration with San Francisco County Transportation Authority (SFCTA), the San Francisco Planning Department and the San Francisco Department of the environment leads the way to implementation of important long-term transit strategies.

12.2 SFMTA SUSTAINABILITY GOALS

1. Contractor shall review SFMTA sustainability goals to align Contractor's approaches, processes, systems, and Equipment with these goals.

2. SFMTA Projects are guided by the ten goals from its Strategic plan:

    a. Identify and reduce disproportionate outcomes and resolve past harm towards marginalized communities.

    b. Create a work environment that is responsive, equitable, and inclusive.

    c. Recruit, hire, and invest in a diverse workforce.

    d. Make streets safer for everyone.

    e. Deliver reliable and equitable transportation services.

    f. Eliminate pollution and greenhouse gas emissions by increasing use of transit, walking, and bicycling.

    g. Build stronger relationships with stakeholders.

    h. Deliver quality projects on-time and on-budget.

    i. Fix things before they break, and modernize systems and infrastructure.

    j. Position the agency for financial success.

12.3 SUSTAINABILITY REQUIREMENTS

1. Contractor shall submit a Sustainability Plan [CDRL].

2. The Sustainability Plan shall:

    a. Describe Contractor's plan to address the potential disruption of SFMTA service caused by sea level rise, coastal erosion, urban flooding, and extreme weather events.

b. Describe Contractor's plan to protect critical infrastructure installed for the Project that could be exposed to damage due to sea level rise, coastal erosion, urban flooding, or extreme weather events.

c. Describe additional Sustainability targets to support SFMTA sustainability goals

d. Describe Contractor's overall sustainability process

e. Describe how Contractor addresses SFMTA Sustainability Goals.

2. SFMTA may periodically audit Contractor to verify that Contractor is following and implementing the Sustainability Plan.

Table 12-15: Transit First Program Goals

Program Area	Goal
Transit	By 2025, increase transit ridership by providing safe, reliable accessible, equitable, rapid, and environmentally sustainable transit service across San Francisco.
Land Use and Transportation	By 2025, reduce Vehicle miles traveled and single occupancy Vehicle Trips through robust and coordinated land use and transportation policies, plans and programming.
Pricing and Congestion Management	By 2025, reduce congestion, Vehicle miles traveled and single occupancy Vehicle Trips through implementation of pricing and congestion management plans, policies, and Projects.
Transportation Demand Management	By 2025, reduce Vehicle miles traveled and single occupancy Trips through implementation of the Transportation Demand Management Plan (TDM) and Program
Complete Streets	By 2025, increase the number of "complete streets" throughout the city which encourages sustainable mode shift, increases safety, and improves the public realm.
Zero Emission Vehicles & Infrastructure	By 2025, increase the number of zero emissions Vehicles in both private and public Vehicle fleets in San Francisco and improve access to charging infrastructure.
Emerging Mobility Services and Technology	By 2025, lay the foundation for a healthy mobility ecosystem that appropriately integrates emerging mobility services and technologies that improves accessibility, affordability, safety, and environmental sustainability.

3. The Transportation Demand Management (TDM) programs and policies are used to overcome barriers to sustainable transit. TDM encourages the community to make environmentally friendly transportation choices. Goals from the TDM Plan include:

a. Goal 1: Make it easy for residents, employees, and visitors to travel by transit, foot, bike, or shared rides when traveling to, from, and in San Francisco

b. Goal 2: Institutionalize a culture in San Francisco that embraces walking, bicycling taking transit and sharing rides.

c. Goal 3: Collaborate on a wide variety of initiatives to leverage the impact of TDM.

d. Goal 4: Ensure and prioritize effective programs through monitoring and evaluation.

12.4 SUSTAINABILITY CDRLS

Table 12-16: Sustainability CDRL Table

CDRL #	CDRL Title
12.01	Sustainability Plan

13 WARRANTY AND SPARE PARTS

13.1 PURPOSE

1. This Section specifies Contractor's obligations to provide CBTC System Warranty and Spare Parts.

13.2 WARRANTY

1. Contractor shall warrant that the CBTC System and its components shall perform as specified in this Agreement for duration of the applicable Warranty Period.

2. During the Warranty Period, Contractor shall provide spare parts and Warranty Services as described in this Section. The cost of providing these parts and services is included in the price. SFMTA has no obligation to pay any additional compensation to Contractor for parts and services that the Agreement requires Contractor to provide under warranty.

3. Regardless of the terms of a manufacturer's pass-through warranty, Contractor shall provide a warranty for all Equipment and Software supplied under this Agreement for a term of not less than eighteen (18) months commencing upon the successful Commissioning for each Phase of the Project.

4. Contractor's warranty shall consolidate all manufacturer warranties for Software and components comprising the CBTC System, such that if SFMTA makes a warranty claim, Contractor shall supply the spare part or Software patch to SFMTA. Contractor may then seek reimbursement from the manufacturer for the claim. SFMTA agrees to cooperate with Contractor's subrogation efforts.

5. Contractor's warranty and support services shall cover all Work on SFMTA Furnished Items performed by Contractor, such as modifications of those items or any software supplied by Contractor that has been installed on those items.

6. Contractor's warranty does not cover work performed by SFMTA or its Installers, but Contractor shall be responsible for the effects of SFMTA Furnished Items on system performance as provided for in Section 9.2 (SFMTA Furnished Items Requirements).

7. There are seven Warranty Periods, one for each Deployment Phase, covering the portion of the CBTC System delivered in each Deployment Phase, as described in Section 8.3.2.7 (Warranty Period). Contractor shall provide Warranty Services which are defined as all the Support Services described in Section 32.4 (Support Services Scope of Work), as well as any additional services defined in this Section 13.2.

8. Each 18-month warranty obligation period shall commence upon the Commissioning of the portion of the CBTC System delivered in each Deployment Phase, with the exception of the Pilot Warranty Period.

9. The Warranty Periods for the Pilot and Subway Replacement Phases shall run concurrently and those Warranty Periods shall commence at Subway Cutover.

10. Central Equipment, onboard Equipment, simulators, and tools provided prior to Subway Cutover shall be covered under the Pilot Warranty Period.

11. Central Equipment, onboard Equipment, simulators, and tools provided after Subway Cutover, if any, shall be covered in the final Warranty Period that immediately precedes Final Acceptance.

12. After expiration of the Warranty Period for each Deployment Phase, Contractor shall provide Support Services for that part of the System as described in Section 32 (Support Services).

13. During the Warranty Period, Contractor shall adjust and maintain the CBTC System as provided in this Agreement so that the CBTC System meets or exceeds Reliability, Availability, and Maintainability Performance Requirements specified in Appendix I to the Agreement.

13.2.1 WARRANTY PLAN AND PROCEDURES

1. Contractor shall develop and submit for SFMTA approval a Warranty Plan [CDRL] and Warranty Procedures [CDRL] that fulfill Contract warranty requirements.

2. The Plan shall incorporate Contractor's warranty requirements, SFMTA Concept of Operation and Maintenance, and Contractor's best practices.

3. The Warranty Plan shall describe:

    a. All Equipment delivered during the Project with the start and expiration of manufacturers warranty and the start and expiration of Contractor warranty, including of any procured Hardware / Software. This list shall include Contractor recommendations to optimize delivery of spare Equipment that may need ongoing maintenance, have potential obsolescence concerns, or other shelf-life concerns.

    b. Contractor's plan for the management, handling, and replacement of spare parts during the installation and testing Phase of the Project

    c. Location and storage of warranty spare parts

    d. Planned parts inventory

    e. Support procedures

    f. A table of all maintenance and warranties provided by all Contractor Equipment Suppliers including dates for any end-of-life or out of Support parts or Software.

    g. Method as to how Contractor will access SFMTA facilities data and report documents

    h. Warranty Services response times

    i. Warranty procedures

    j. Warranty issue allocation and adjudication methods, issue tracking and closure methods and other report formats

    k. A schedule of the implementation of the Warranty Plan.

    l. Warranty Service reporting and metrics.

    m. Any other provisions necessary for Contractor to provide the required Warranty Services

4. Warranty procedures shall include:

    a. Instructions for filing and completing warranty claims

    b. Forms, reports, shipping and receiving instructions

    c. Procedures to support claims processing, payments, and reimbursements in accordance with Contract requirements

d. Other administrative details needed for SFMTA personnel to obtain Warranty Services

13.2.2 FAILURE REPORTING AND CORRECTIVE ACTION SYSTEM

1. Contractor shall submit a Failure Reporting and Corrective Actions System (FRACAS) as specified in Section 30.

2. Contractor shall maintain an up-to-date Warranty-item Tracking Database and Report [CDRL] in compliance with the FRACAS process.

3. SFMTA shall have access to the database to review CBTC System Performance Requirements at any time during the Warranty Period.

13.3 SUPPORT SERVICES AND SPARE PARTS

1. Contractor shall supply all spare parts and/or repair of spare parts for the portion of the System installed in each Deployment Phase until expiration of the Warranty Period.

2. If any part or installation thereof proves defective due to non-conforming quality or quantity required in design, materials, workmanship, Software, or Configuration during the term of this Contract, Contractor shall take immediate actions to correct all identified defects.

3. Contractor shall use the FRACAS process to track and correct identified System defects.

4. Contractor shall monitor parts failure data and produce trend analyses to identify on-going fleet and systemwide defects.

5. Contractor shall analyze and provide fleet and systemwide corrective action, including fleet or systemwide retrofit, for any component or subsystem that has a failure rate greater than 10% of that specified for that component or subsystem.

13.3.1 SPARE PARTS QUANTITIES

1. During the term of this Contract, Contractor is responsible for handling (when stored in Contractor's warehouse) and replenishing the spare parts. Contractor shall develop and manage the delivery process and provide availability of spare parts to meet the CBTC RAM targets and System Performance requirements.

2. The CBTC System will be Commissioned in Deployment Phases, meaning the Migration will span over several years. During the Deployment Phases, Contractor shall maintain two separate inventories, one for installation and testing (the "Installation and Testing Inventory"), and one for the parts of the System already in Revenue Service (the "Spare Parts Inventory").

3. Contractor shall use the Spare Parts Inventory to satisfy both the warranty provisions and the Support provisions after warranty expiration.

4. Contractor shall maintain a sufficient quantity of spare parts on hand from the Installation and Testing Inventory to accomplish the testing and Commissioning without incurring delays. Delays from the Contract Schedule or impacts to Reliability or Performance Targets caused by parts availability, including shipping delays, is the responsibility of Contractor.

5. For the Spare Parts Inventory:

a. Contractor shall maintain two (2) years' worth of spare parts, according to the RAM predictions, or 15% of Project-wide installed parts that are identified for spares, whichever is greater.

b. The required Spare Parts Inventory quantities will change each time a Deployment Phase is Commissioned. The Spare Parts Inventory quantities for Support will be established at the end of the last Deployment Phase. Contractor shall review the Spare Parts Inventory quantities with SFMTA prior to supplying spare parts for each Warranty Phase.

c. Contractor shall supply spare parts no later than 365 Days before the start of each Warranty Period.

d. Contractor shall submit supporting analyses and historical data to support the spares quantities at the request of SFMTA.

6. In addition to the CBTC System spare parts, Contractor shall provide spares of all Special Tools and test equipment as specified in Section 21 (Simulators and Tools).

7. The spare parts provided through this Contract are the property of SFMTA, whether or not they are housed in Contractor's warehouse or on SFMTA premises. Within 120 days of the termination of this Contract, Contractor shall deliver all spare parts purchased by Contractor, regardless of their location, to SFMTA.

8. Contractor shall submit a List of Parts [CDRL] that specifies all parts of the CBTC System.

9. Contractor shall identify spare parts as a subset of the List of Parts.

10. Contractor shall supply and maintain inventory for spare Equipment identified in the List of Parts.

11. The List of Parts shall:

a. List all physical parts, assemblies, and subassemblies of the CBTC System.

b. All Software provided as part of the CBTC System

c. Contractor shall associate Software with its applicable Hardware component

d. Group parts according to the CBTC System Architecture by subsystems and assemblies and subassemblies.

e. Provide details as a hierarchical indented bill of material

f. List the Line Replaceable Units (LRU) and Lowest Line Replaceable Units (LLRU) that are to be repaired or replaced

g. Include the following categories:

i. Repairable spare parts that are the replacement assemblies, parts or items which may be serviced by SFMTA or returned to the Contractor for refurbishment or replacement during warranty.

ii. Consumable spare parts: items with a life expectancy of less than five years and/or under a $ 2,500 value.

iii. Exchange assemblies that are Line Replaceable Units (LRUs) i.e., are assemblies which will be exchanged with functioning units for installed Equipment, and which must be inventoried as complete LRU assemblies.

h. Identify all parts and quantity of parts SFMTA shall maintain as inventory on SFMTA property.

i. Identify all parts and quantity of parts Contractor shall maintain as inventory in Contractor provided warehouse.

j. Identify all parts and quantity of parts not originally furnished under this Contract, but which are part of the complete CBTC System, such as the VOBCs.

k. Identify the sustainable disposal method required by California for the removed faulty part or unit

l. For each Deployment Phase of the CBTC System, Contractor shall submit any updates or changes to this List of Parts to SFMTA.

m. List consumable items, Special Tools, special testing equipment (see Section 21.3) and their applicable parts/units required to maintain the CBTC System.

12. The List of Parts shall include, but not be limited to, the following data:

a. Product/part name, description, manufacturer/Contractor catalog number

b. An illustration of the part

c. Manufacturer or Supplier's serial number, revision level, or other identification

d. Space for SFMTA to provide assigned part number and bar code

e. Description of the part, including a note as to whether it is a sealed unit or whether it is an assembly or sub assembly which can be broken down into component parts

f. Date of manufacture.

g. Expected utilization in 12 months

h. Overall dimensions and weight including packing, if any, for shelf space purposes

i. Special storage conditions

j. Identify interchangeability with similar parts from other component Suppliers

k. The source/OEM - the manufacturer's name and address and that of its agent where appropriate

l. The normal manufacturing and shipment lead times

m. Identify if the part is a spare part

n. Identify if the part is Software

o. For each spare part, recommended quantity at each required SFMTA storage location

p. Price per part and total price based on order quantity

q. Identify if the spare part includes Vital or non-Vital Hardware or Software

r. Identify if the spare part is either "repairable", "non-repairable", "consumable" or "One-Time Limited Service" spares

s. Identify the length of the shelf life.

13.3.2 MAINTENANCE MANAGEMENT SYSTEM

1. Contractor shall supply an Asset Management System (AMS) as specified in Section 20.2 (Centralized Maintenance Management System).

2. The AMS diagnostic functions shall use key metrics required by the performance calculations specified in Section 30 (Reliability, Availability and Maintainability) to measure the CBTC System RAM Performance.

3. The AMS shall interface with SFMTA Enterprise Asset Management System (EAMS) as specified in Sections 20 and 28, providing all necessary data to support:

    a. Parts management and storage

    b. Repairs

    c. Shelf-life monitoring

    d. Work orders

13.3.3 INSPECTION AND TEST OF SPARES

1. Contractor shall manufacture, test, and deliver spare parts Equipment to a SFMTA storage facility as directed by SFMTA.

2. Contractor shall suitably pack and identify the Equipment for prolonged storage.

3. SFMTA reserves the right to inspect and/or test spare parts Equipment on receipt and re-package if necessary. If any part is deemed defective upon inspection or test, Contractor shall replace the part at Contractor's sole expense.

13.3.4 SYSTEM MODIFICATIONS

1. In the event Contractor makes any modifications to any System components, parts, Software or Third-Party System integrations prior to Final Acceptance, Contractor shall, at no cost to SFMTA, either:

    a. Make the same modifications to all affected spare parts, Software and Third-Party System integrations, whether delivered or not, or;

    b. Collect all affected spare parts, Software and Third-Party System integrations, and replace them with new spare parts, Software, and Third-Party System integrations which incorporate the modifications.

2. In the event any modifications to the design prior to Final Acceptance replace a part, rack, assembly, subsystem or component with a different part, rack, assembly, subsystem or component, such that spare parts delivered to SFMTA cannot be used, Contractor shall, at no cost to SFMTA:

    a. Collect the defunct spare parts and replace them with parts that can be used in the current System design, and;

    b. Provide spare parts to be used to replace those currently installed as part of the System.

13.4 SPARE PARTS HANDLING

13.4.1 SPARE PARTS DELIVERY

1. The Contractor shall develop and provide a monthly schedule of all Equipment to be delivered to SFMTA locations during Warranty and Support.

2. The schedule shall submit the part number, description, size, delivery location, expected delivery date, actual delivery date and confirmation detail of delivered items. SFMTA will provide to Contractor a delivery notice with SFMTA assigned part numbers and designated delivery locations for all Contractor delivered items.

3. The initial monthly schedule shall be included in the Warranty Plan and Support Management Plan.

13.4.2 SPARE PARTS STORAGE

1. Contractor shall maintain the full quantity of spare parts identified in Section 13.3.1 in the San Francisco Bay Area, either on SFMTA premises or in a warehouse location to be provided by Contractor, for the Contract Term.

2. Contractor's storage of parts, Special Tools, and test equipment shall comply with the storage requirements specified by the manufacturer.

3. SFMTA will identify the locations on SFMTA premises where Contractor may store spare parts. SFMTA may adjust, from time to time, the locations on its premises where spare parts are stored, and the quantity of parts SFMTA is able to store on its premises. Contractor shall store parts in excess of those SFMTA is able to store on its premises at Contractor's location.

4. Authorized SFMTA staff shall have access to Contractor-stored spare parts at any time.

5. Contractor shall ensure the location where the spares are kept does not compromise Contractor's response time, time to resolve, and other Performance Requirements.

6. The AMS and EAMS shall record the location of every Contractor-provided spare part, as specified in Sections 20 (Maintenance and Diagnostic Functions) and 28 (Interface Requirements Specifications).

7. All temporary storage must be approved by SFMTA prior to delivery.

13.5 EQUIPMENT ASSET MANAGEMENT

13.5.1 EQUIPMENT ASSET MANAGEMENT INTEGRATION

1. Contractor shall develop an Equipment Asset Management System Integration Management Plan [CDRL].

2. Contractor shall integrate additional Contractor provided EAMS functionality with SFMTA's existing EAMS and the new CBTC System AMS. Section 28 specifies the EAMS and AMS interface requirements.

3. Contractor shall electronically create, populate and complete an Asset Register [CDRL].

4. The Asset Register shall contain asset descriptions and characteristics, including an indication of whether the asset is new or existing modified under the CBTC System Deployment.

5. Contractor shall collaborate with SFMTA to determine the format to be used to electronically upload the Asset Register data to SFMTA EAMS.

6. Contractor shall submit the Asset Register to SFMTA before Revenue Service for each Deployment Phase as input to SFMTA EAMS.

7. During the term of the Contract, Contractor shall submit to SFMTA any updates and changes to the Asset Register on a quarterly basis, at a minimum, through System Acceptance.

13.5.2 SYSTEM ACCOUNTING

1. SFMTA tracks assets as a tangible financial asset or an intangible financial asset. Financial assets are all parts described in the List of Parts that are not considered as Spare Parts. Tangible financial assets are parts considered to have physical form such as equipment and machinery, while intangible financial assets are parts considered to be non-physical such as Software and work hours. Contractor shall review, with the help of SFMTA, all CBTC Equipment in the List of Parts and identify assets considered to be Software.

2. Contractor shall submit before Revenue Service for each Deployment Phase, an Intangible Financial Assets List [CDRL].

3. The Intangible Financial Assets List shall include:

    a. Financial asset list description

    b. Estimated cost for each financial asset.

4. Upon SFMTA approval of the List of Parts and the Intangible Financial Asset List, SFMTA may input these lists into SFMTA EAMS. SFMTA EAMS System will provide a unique fixed Asset ID for ongoing use in the Project and SFMTA.

13.6 WARRANTY AND SPARE PARTS CDRLS

Table 13-17: Warranty and Spare Parts CDRL Table

CDRL #	CDRL Title
13.01	Warranty Plan
13.02	Warranty Procedures
13.03	Warranty Item Tracking Database and Report
13.04	List of Parts
13.05	Barcoding Plan
13.06	Safety Data Sheets (SDS)
13.07	Equipment Asset Management System Integration Plan
13.08	Asset Register
13.09	Intangible Financial Assets List

14 OBSOLESCENCE MANAGEMENT

14.1 PURPOSE

1. This Section specifies Contractor's obligations to design, manage and warrant the CBTC System so that it operates in accordance with the Performance Requirements stated in this Contract for a period of twenty (20) years following Final Acceptance.

14.2 OBSOLESCENCE REQUIREMENTS

1. Contractor shall develop and implement an Obsolescence Management Plan (OMP) to ensure the entire CBTC System including its associated network, operates in accordance with the Performance Requirements stated in this Contract for a period of twenty (20) years following Final Acceptance.

2. Contractor shall publish release for manufacture dates for CBTC System Equipment and the spare parts, including Special Tools and test equipment required for maintenance, at the latest practical date to meet the Project Schedule.

3. Contractor shall identify the release for manufacture dates in the Project Schedule, the Project Schedule and in schedule updates required by the Contract.

4. Contractor shall ensure the availability of all CBTC System Software, spare parts, and CBTC Components for a period of twenty (20) years following Final Acceptance.

5. If CBTC Components, spare parts, or CBTC System Software are not available at any time during the Support Term, Contractor shall make available substitutes (subject to SFMTA approval) of service-proven functional equivalent (or better) items.

6. Within 30 days after NTP, Contractor shall submit a list of sole source parts Suppliers for SFMTA approval.

7. Contractor shall actively manage the supply of CBTC System Equipment and Software to identify components, Software, firmware or other System elements that may or are likely to become obsolete prior to the expiration of the Support Term (including Options).

8. Contractor shall notify SFMTA not less than two years in advance of planned or known obsolescence of any CBTC System element.

9. Contractor shall submit for SFMTA approval recommendations and plans for Upgrade paths, redesign of Equipment (form, fit, and functional replacements), and the purchase of sufficient replacement components and spare parts to ensure that the CBTC performance and operations will meet the Contract requirements for the Contract Term.

10. Contractor shall update O&M manuals, parts lists and training courses for any Equipment or CBTC component replaced due to obsolescence.

14.3 OBSOLESCENCE DEFINITION

1. Any part, component, system, sub-system, assembly, spare part, device, or other component of the CBTC System, whether or not considered consumable, in Contractor's Scope of Supply is obsolete:

    a. When supply of a component may only be obtained on commercial terms exceeding 10% of its price at Final Acceptance (excluding inflation). Inflation shall be calculated using the

Material Adjustment Factor as described in Appendix B2.3.1.3 (Economic Price Adjustment Calculation) to the Agreement.

b. When manufacturer or supply chain lead times grow in excess of three months greater than the Contractor specified lead time in the List of Parts.

c. When supply may only be obtained or secured via a Public Marketplace (including but not restricted to, eBay).

d. If the component includes Software stored in memory, when the only Software compatible with that component has reached End of Support.

2. Contractor shall consider Software obsolete when it has reached End of Support.

14.4 OBSOLESCENCE MANAGEMENT PLAN

1. Contractor shall submit an Obsolescence Management Plan (OMP) [CDRL] that describes Contractor's plan and approach to ensure that CBTC System performance during the Contract Term will not be degraded by the Obsolescence of any System component or Software.

2. Contractor shall review the Obsolescence Management Plan with SFMTA and revise as needed in response to SFMTA comments:

   a. At Preliminary Design Review

   b. At System Final Design Review

   c. Immediately prior to and as a condition of, Final Acceptance

   d. Annually during the Support Term, on each anniversary of Final Acceptance.

3. The OMP shall include the following information:

   a. Descriptions of recommended obsolescence management plan and activities for:

      i. all CBTC System parts, and components thereof;

      ii. all required CBTC System Commercial Off-the-Shelf Software (COTS);

      iii. all CBTC System Software;

      iv. all Special Tools and test equipment;

      v. all spare parts required for the implementation and maintenance of the CBTC System;

      vi. all ongoing required integration of all CBTC System elements.

   b. Descriptions of design requirements and criteria to be considered during the design and implementation of the Project to ensure that potential future changes in technology will not impact Reliability, Availability, Maintainability, and Safety performance of the System, and to ensure that the System will continue to perform within Contract requirements for the Contract Term.

   c. A description of Contractor's obsolescence management strategies such as lifetime buys, last time buys, joint procurements, or substitution of obsolete Equipment with the latest compatible technology (e.g. network devices) to ensure that CBTC spare parts and Software Updates and Upgrades will be available to maintain CBTC System performance within

Contract requirements for the Contract Term. Link these strategies to specific elements in the List of Parts.

d. A list of items and components from the List of Parts specified in Section 13 (Warranty and Spare Parts) and Software applications that are part of the CBTC System, including Special Tools and test equipment required for maintenance, that have high obsolescence risk and describe Contractor's obsolescence management plan and activities for those higher risk items. For each item identified with high obsolescence risk, Contractor shall address:

    i. Average life span,

    ii. Forecasted obsolescence date,

    iii. Supplier contact information, and

    iv. Component availability.

e. A list of any sole source products and their Suppliers [CDRL].

f. Descriptions of the process by which Contractor will determining whether and estimating when CBTC System Equipment and the spare parts required for maintenance will become obsolete. This process shall include a schedule of periodic reviews that Contractor will perform over the Contract Term.

g. A list of items that are at risk of becoming obsolete in the following periods:

    i. Within the 5 (five) years from the date of Final Acceptance

    ii. Within the 10 (ten) years from the date of Final Acceptance

    iii. Within the 20 (twenty) years from the date of Final Acceptance

h. Mapping of the SFMTA's CBTC System in Contractor's CBTC Product Roadmap showing at which stage of the Base Product life cycle the proposed CBTC System is and showing the expected launch of the next generation of Base Product Hardware and Software specified in the System design.

i. Identification of any procurement strategies to be considered.

j. Recommendations for Hardware replacements or upgrades which are required for compatibility with the latest version of Software, if the current Hardware is incompatible with that version.

k. A list of replacement components that conform to the Contract requirements for Equipment or subsystem elements (e.g. Software), including COTS items, identified as expected to be obsolete. For each replacement component listed, Contractor shall:

    i. Submit a comparison of the new Equipment or new Software detailing all differences in the specifications, testing, performance, capabilities, and Standards;

    ii. Identify all of the component or part vendors; and

    iii. Identify all impacts to the Contract or the Project Schedule associated with the implementation of the proposed Equipment.

14.5 OBSOLESCENCE MANAGEMENT CDRLS

Table 14-18: Obsolescence Management CDRL Table

CDRL #	CDRL Title
14.01	Obsolescence Management Plan (OMP)
14.02	Sole source products listing

15 CHANGE CONTROL PROCEDURES

15.1 PURPOSE

1. The CBTC System is both a technology system and a safety-critical component of SFMTA's railway. To meet best practices and safety regulation requirements, SFMTA has existing Change Control Processes for both changes to technology systems, including Hardware and Software, and changes to transit operations and procedures. The CBTC System will be subject to both processes in all stages and Phases of System design and implementation.

2. Appendix J to the Agreement contains the current version of SFMTA Technology Solutions and Integration Department's Change Control Policy and Procedure, as well as SFMTA System Safety Rail Change Control Board Standard Operating Procedure (SOP). This Section 15 establishes Contractor requirements to comply with both procedures.

    a. SFMTA may update its policies and procedures and reissue them to Contractor as they are revised over the Contract Term. Contractor shall always follow the most current SFMTA policies and procedures in effect for the term of this Agreement.

3. The Work that Contractor shall perform under the Agreement will be considered changes to the SFMTA's transit system and technology systems. Sections 15.2 and 15.3 cover the review of the Work in this context and the use of the word "change" in these sections does not refer to project Change Orders or Contract Modifications. Section 15.4 covers the project review process for design changes, CORs, PCCs, and Contract Modifications as further described in that Section.

15.2 CHANGE CONTROL BOARD PROCEDURES

1. The SFMTA Change Control Board exists to review proposed changes to the SFMTA transit system alignment, storage facilities, and all modes of transit equipment and functions as a requirement of SFMTA's compliance with California state law, (including CPUC regulations) and federal law. Contractor shall comply with SFMTA Change Control Board Procedure provided in Appendix J to the Agreement and instructions from SFMTA Change Control Board.

2. Contractor shall prepare a Change Control Board (CCB) change request following each Deployment Phase's Construction Final Design Review, describing the Work required to implement the System design for that Deployment Phase. These CCB change requests shall include:

    a. Brief description of the portion of the CBTC System to be delivered in the Deployment Phase.

    b. The design package developed during Construction Final Design for that Deployment Phase.

    c. Description of CBTC System functionality following the change described in the Change Request.

    d. A summary of the Project Schedule for that Deployment Phase, including resources necessary to complete the proposed Work in that Phase.

    e. Impacts to transit operations arising from the proposed Work during installation, to include Closures included in the Project Schedule.

    f. Any safety and security concerns of the proposed Work

g. A hazards analysis which considers safety and security implications, when applicable, in accordance with Section 5.1 of the SFMTA Public Transportation Safety Plan (PTASP)

3. Contractor shall also prepare a CCB change request prior to the Commissioning of a Deployment Phase into Revenue Service, covering the changes to transit operations and procedures necessary to operate the System, which shall include:

   a. Brief description of the portion of the CBTC System delivered in the Deployment Phase.

   b. A summary of the testing and Commissioning activities completed to date, including Safety Certification documentation, test procedures and test reports for that Deployment Phase.

   c. Description of CBTC System functionality for that Deployment Phase, including the changes to transit operations and procedures that will result from cutting over and decommissioning the ATCS and/or legacy signaling systems (in the area covered by the Deployment Phase).

   d. A summary of the remaining tasks necessary to complete the Commissioning of the Deployment Phase.

   e. Any safety and security implications of the proposed Work.

   f. Drawings, either as-built, redlined, or the most current construction drawings for the applicable Deployment Phase.

4. During the Support Term, Changes approved by the CBTC Change Control Committee (CCCC) shall subsequently be submitted to the Change Control Board for final approval.

5. Contractor shall use the Change Request Form included in the Change Control Board Procedures provided in Appendix J to prepare CCB change requests.

6. SFMTA Change Control Board meetings are typically held on a monthly basis. Contractor shall include the required Change Control Board meetings in the Project Schedule prior to the applicable Milestones (Construction Final Design and Commissioning).

7. Where following the regular Change Control Board meeting schedule would result in a Delay to the Work of more than one week, Contractor shall communicate this to SFMTA Project Manager so that SFMTA Project Manager may convene a special meeting of the Change Control Board.

8. Not more than three Contractor representatives may attend the Change Control Board meeting. Contractor's representatives must be knowledgeable about the material contained in the CCB change request and be able to answer Board members' questions.

15.3 TECHNOLOGY CHANGE ADVISORY BOARD PROCEDURES

1. The Technology Change Advisory Board (CAB) is the change management decision making authority for SFMTA TSI and is accountable to SFMTA Chief Technology Officer (CTO). Contractor shall comply with SFMTA CAB Policy and Procedures set out in Appendix J to the Agreement.

2. The CAB reviews and approves all requests for high-risk and high impact changes to technology systems. Many of the activities described in these Specifications will require CAB approval.

3. Contractor shall submit CAB change requests for approval when specified in a requirement to this Specification, or when a Hardware or Software change is proposed for a technology system that is in production or Revenue Service, or when new Hardware is connected to the SFMTA network or any

device that is in production or Revenue Service. Contractor shall not proceed with any such activities without SFMTA approval.

4. Following the Pilot Deployment Phase Commissioning, the central CBTC Equipment will be in Revenue Service. Contractor shall submit CAB change requests for each Software and Central Equipment update commencing from the time Central Equipment is put into Revenue Service.

5. The CAB typically meets every Thursday. Contractor shall include the CAB process in its Project Schedule for Project activities requiring CAB review. Submitted CAB change requests will be reviewed at the next Thursday meeting.

6. Contractor shall have at least one representative attend the CAB meeting who is knowledgeable about the material contained in the CAB change requests and can answer CAB members' questions.

7. Contractor shall submit the following information prior to the CAB meeting as part of a CAB change request:

    a. Narrative describing the change

    b. The affected System, subsystem and elements

    c. Details of the change, such as Software version or patch number.

    d. Testing history, such as SAT, FAT, etc., including documentation

    e. Approval from SFMTA Project Manager for the change

    f. Resource plan – who will conduct the change, who will monitor, who will receive communications per the communications plan

    g. Communications plan, providing for 72-hour notice, 24-hour notice, notice of start of the change, progress updates during the change, troubleshooting updates, and an "All Clear" Communication

    h. The date and time a Go/No-Go decision will be made to execute the change, and who will make the decision.

    i. A risk assessment, addressing the SFMTA technology systems and services that may be affected by the change, the probability they will be affected and a description of how they will be affected.

    j. The installation plan, including, verification, regression, or other tests planned by Contractor.

    k. A rollback plan, including procedures for executing a rollback and criteria for initiating the rollback procedure.

16 SYSTEM ARCHITECTURE, FUNCTIONS, AND PERFORMANCE

16.1 PURPOSE

1. This Section describes System Performance, System Level Functions and System Architecture requirements of the CBTC System.

16.2 SYSTEM ARCHITECTURE

1. Contractor shall develop a CBTC System Architecture [CDRL] that complies with the Contract requirements and with the IEEE 1474 Standard.

2. The CBTC System Architecture shall integrate the following subsystems:

    a. Train Control and Supervision

    b. Data Communication

    c. Centralized Maintenance Management

    d. Tools and Simulation

    e. Master Clock

    f. External interfaces

    g. Data flow and required timing diagrams through the integrated CBTC System

    h. Interfaces to Third-Party Systems

    i. Cloud based applications or data systems

3. The CBTC Control Center Equipment will be installed at the Transportation Management Center (TMC) complex at 1455 Market Street, which is the primary Control Center.

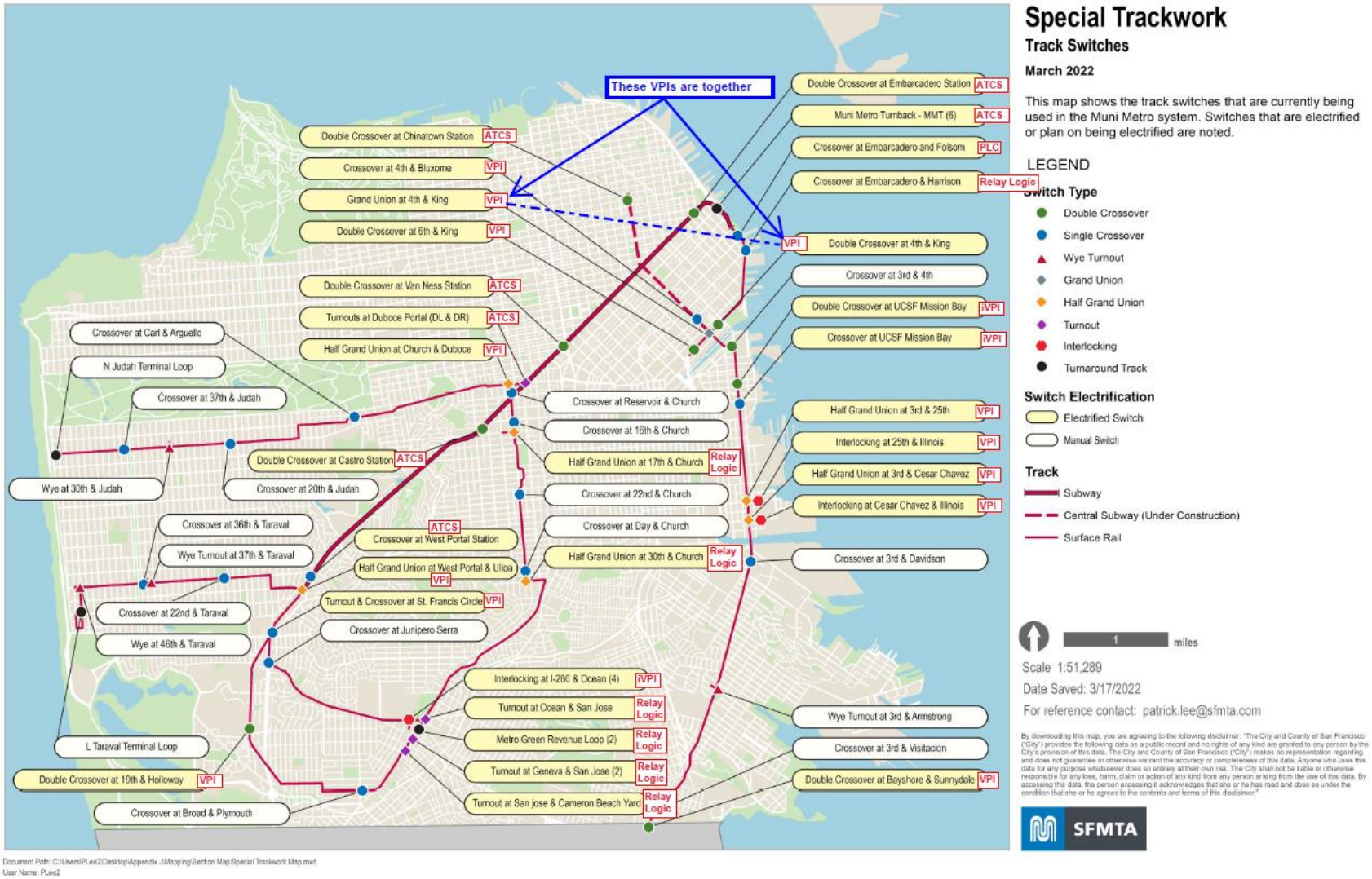
4. Contractor shall supply a functional replica of the primary Control Center as a cold stand-by backup Control Center in the former Operations Control Center (OCC) facility at 131 Lenox Way.

5. The replica installed in the OCC backup shall be fully functional and shall serve in place of the primary Control Center during disaster recovery, in the event of a failure affecting the primary Control Center or in case of evacuation of the primary Control Center.

6. The replica installed in the OCC backup Control Center shall be a full featured ATS simulator for staff training purposes when the OCC is not in use as a Control Center. See Section 21.2 (Simulators) for specific requirements.

7. Figure 16-1 shows the SFMTA Metro Track Map. Electrically actuated switches are highlighted in yellow. Crossovers that are not highlighted are operated with manual switches. All switches shall be included in the ATS scope as described in this Section.

Figure 16-2 SFMTA Metro System Track Map with Interlockings



8. Figure 16-1 identifies the type of Interlocking that controls each electric switch. In addition to the switches and Interlockings depicted in Figure 16-1, there are two VPI Interlockings associated with the freight rail crossings at 3rd & Carroll Sts and 3rd & Cargo Way. These two Interlockings do not control any switches and are not shown in Figure 16-1, but are part of the CBTC Scope. See Section 28.10 (Freight Crossing) for more information.

9. The CBTC System shall centrally control all non-manual switches, with the exception of yard switches.

10. The CBTC System shall control all surface Interlockings via its VOBC, associated Zone Controller, and Object Controller.

11. Contractor shall supply Interlocking Equipment as described in Section 27.8.2 (Interlocking).

12. The CBTC System shall vitally interface to the Drawbridges and freight railroad crossings described in Section 28 (Interface Requirements Specifications) and the Concept of Operations and Maintenance either by integrating the existing equipment with the CBTC System or by replacing the existing Equipment with Contractor's Equipment.

13. All Interlockings shall have local control over rail signals, switch machines, and any wayside signaling equipment in its area of control.

14. All wayside equipment controlled by the Interlockings are SFMTA Furnished Items as described in Section 9.3 (Permanent SFMTA Furnished Items). Contractor shall evaluate the condition of this equipment and may recommend that SFMTA replace it. In this recommendation, Contractor shall describe to SFMTA the expected improvement in System Reliability, Availability and Maintainability metrics or other benefits of doing so.

15. Contractor shall price up to 10 additional Interlocking Equipment kits (7 manually operated crossovers and 3 manually operated wye turnouts) on a per-Interlocking basis and SFMTA may exercise the option (Option 4) to purchase between 0 and 10 additional Interlocking Equipment kits. The specific location and other details about the additional Interlockings will be specified by SFMTA during design. Contractor shall include in the per-kit price:

    a. Equipment and design services associated with converting these junctions to CBTC System Interlocking-controlled junctions. SFMTA will supply wayside equipment, such as switch machines and signals, necessary to motorize these junctions as set out in Section 9.3 (Permanent SFMTA Furnished Items).

    b. Integration with traffic signals as described in Section 27.8.2 (Interlockings).

16. Contractor shall evaluate the presence of manual switches in CBTC Territory against the CBTC Concept of Operations during the Design Phase.

17. As part of the PDR Submittal, Contractor shall recommend which, if any, manual switches SFMTA should motorize to facilitate the goals of the design articulated in these Contract Specifications or the CBTC Concept of Operations.

18. The ATS subsystem shall support the Route Setting Functions described in Section 17.5.1 using any switch shown in Figure 16-1, including manual switches.

    a. Routing functions including manual switches shall be non-vital.

b. The Contractor shall furnish any Equipment necessary to meet this requirement.

19. Contractor shall design the CBTC System architecture such that the normal operation of the System shall continue in presence of any single point failure (See Section 30).

20. The System Architecture shall use a consistent standard structure of subsystem and component naming conventions developed by Contractor.

21. Contractor shall design and Furnish all power distribution and Uninterruptible Power Supply (UPS) equipment necessary for proper operation of all Contractor-furnished CBTC Equipment.

22. If Contractor-furnished Equipment will be located in an existing SFMTA-furnished cabinet, rack or data center, Contractor shall coordinate this design with SFMTA.

23. All Contractor-provided UPS units shall provide a minimum of 4 hours of autonomy time for the connected equipment.

16.3 SYSTEM FUNCTIONS

1. Contractor shall submit a CBTC System Functional Specification [CDRL] that complies with Contract requirements as part of the System Design Documents included in the Preliminary Design Review package.

16.3.1 TRAIN CONTROL AND SUPERVISION

1. The CBTC System's Automatic Train Supervision (ATS), Automatic Train Operation (ATO) and Automatic Train Protection (ATP) functions shall conform to Contract Specifications Sections 17, 18 and 19.

2. ATP functions shall ensure fail-safe protection against collisions, excessive speed, and all other Hazardous conditions identified in the Hazard Log (See Section 6.3).

3. ATP functions shall have precedence over both the ATO and ATS functions.

4. Contractor shall design the Vital ATP functions to continuously detect the presence of CBTC-equipped Vehicles when operating in ATO and UTO Territory.

5. Contractor shall design the ATS subsystem/functions to continuously detect the presence of all CBTC-equipped Vehicles operating on the surface.

6. The CBTC System shall have full bidirectional functionality to allow Trains to run on a single track on an alternate direction basis, or by fleeting of Trains in one direction followed by fleeting of Trains in the opposite direction, on all tracks in the following sections of the Muni rail network:

    a. The Market Street Subway (including Twin Peaks and MMT)

    b. Central Subway

    c. The Pilot Phase area, as set out in Section 2.3.

    d. The portion of the J Expansion Phase area from the crossover at 16th and Church northwards.

7. The CBTC System shall support reverse running in the areas designated for bidirectional functionality in this Section. Contractor shall:

a. Design the System to support reverse running in the areas designated for bidirectional functionality in this Section,

b. Furnish all Equipment necessary to implement reverse running that is not identified in Section 9.3 (Permanent SFMTA Furnished Items) as being furnished by the SFMTA, and

c. Identify all SFMTA Furnished Items necessary to implement reverse running in the System Design Documents. Technical specifications for SFMTA's existing switches are included in the Reference Materials.

8. The CBTC System shall have manual override functions that Transportation Controllers may use to configure the number of LRVs in sections of track where the number of LRVs is limited by tunnel ventilation or traction power restrictions, as specified in Section 17 (ATS Functions).

9. Contractor shall establish contiguous zones where the same Train operating modes (UTO, ATO, ATPM, and Manual) apply to normal operations, as described in Section 22 (Modes of Operation). These zones shall be based on Contract requirements and SFMTA operating rules.

10. Contractor shall assign a single operating mode for normal operations and specify which operating modes are available for degraded operations in each zone.

16.3.1.1 ENTERING/EXITING CBTC TERRITORY

1. The Contractor shall design the System so that:

   a. LRVs enter and exit CBTC Territory as they pull out from the MME and Green Yards.

   b. Heritage Vehicles enter and exit CBTC Territory at the MME, Green and Cameron Beach yards and at the transition areas described in Section 22.6.4 (Entering and Exiting CBTC Territory).

   c. Maintenance Vehicles may enter and exit CBTC supervision anywhere in CBTC Territory.

2. The CBTC System shall automatically obtain the Block ID for the Vehicle's daily assignment from the CAD/AVL System as part of CBTC initialization prior to the Vehicle's pull-out from the yard:

   a. Block ID – if needed to be different from the one assigned automatically by the CAD System

   b. Number of cars in the Consist

3. If the CBTC System cannot obtain the Block ID, the System shall prompt the Train Operator to enter it.

4. The System shall allow the Train Operator to decline to enter a Block ID.

5. If a Train’s Block ID is not obtained from the CAD/AVL system or manually entered, the CBTC System shall set the Consist ID to the Train ID.

6. The CBTC System shall automatically obtain the number of cars in the LRV Consist from the LRV Trainline as part of CBTC initialization prior to the Train's pull-out from the yard.

7. If the CBTC System cannot obtain the number of cars in the LRV Consist, the System shall prompt the Train Operator to enter this information.

8. The CBTC System shall perform initialization checks for equipped Trains entering CBTC Territory in the transition areas defined in Section 22.6.4 (Entering and Exiting CBTC Territory) to verify the proper operation of the onboard CBTC Equipment prior to entering the revenue tracks, meeting the following requirements:

    a. If the initialization checks are passed, an indication shall be provided to the Train Operator.

    b. If the initialization checks reveal a Service Affecting Failure that will prevent the Train from using the CBTC System in Revenue Service, the System shall annunciate this failure to the Train Operator, the AMS Workstation, and the ATS user interface, and the CBTC shall not allow the Train to enter the CBTC Territory.

    c. Service Affecting Failure Annunciations shall provide sufficient information to identify the general category of fault to maintenance.

    d. The System shall make the results of Train initialization checks available through the AMS Workstation and ATS user interface.

9. As Trains are approaching the exit of CBTC Territory, the CBTC System shall provide a visual indication to the Train Operator of time and/or distance until the Train will be exiting the CBTC Territory on the TOD.

10. When a Maintenance Vehicle is ready to exit CBTC Territory, its VOBC will be turned off as described in Section 2.4.3 (Maintenance Vehicles), the steel wheels lifted, and the vehicle driven off the track. The CBTC System shall respond to this occurrence in the following ways:

    a. The ZC shall create an NCO corresponding to the non-communicating Maintenance Vehicle.

    b. The MCG of the Maintenance Vehicle shall continue to report GPS coordinates to the ATS.

    c. The ATS shall continue to display the non-communicating Maintenance Vehicle.

    d. The ATS shall either present the non-communicating Maintenance Vehicle's location along the guideway or display an indication to the Transportation Controller that the Maintenance Vehicle has left the guideway based on this information.

11. The ATS shall provide a secure command enabling Transportation Controllers to remove NCOs associated with Maintenance Vehicles to remove the need for sweeping the track previously occupied by the Maintenance Vehicle.

16.3.1.2 INTERLOCKING FUNCTIONS

1. Contractor shall design the CBTC System to integrate Vital Interlocking functionalities via the Zone Controller and Object Controllers associated with each Interlocking to control rail signals, switch machines and other signaling Equipment.

2. The Contractor shall design a vital means for Vehicle detection and location through the area controlled by surface Interlockings via its VOBC, and the Zone Controller and Object Controllers associated with each Interlocking.

3. The design of the system shall comply in every respect with the Code of Federal Regulations (CFR) 49 the portions that are Governing Railroad Signal and Train Control Systems as issued by the office of Safety, Federal Railroad Administration, latest publication at the time of award, and of any supplements thereof that become effective before this Contract is awarded.

4. Interlocking functions shall include:

    a. Approach locking: Guideway elements shall be reserved for a Vehicle that has a movement authority over the element. The guideway element shall remain reserved until the Vehicle drives past the element or stops and the movement authority is pulled back.

    b. Over-switch locking: Over-switch locking shall be activated due to a communicating Train or an NCO overlapping the associated over-switch blocks. If over-switch locking is activated, no automatic switch movement shall be allowed. The system shall allow a manual switch move, through a secure command, if NCO Over-switch locking is activated. This is to allow the Transportation Controller to change the switch position such that a communicating Train in Manual Mode can, if required, sweep both branches of the switch and clear the NCO also preventing Vehicle derailment caused by switch maneuvering.

    c. Flank protection: This is the locking of a switch in a position to protect the flank of another route to prevent a potential sideswipe hazard with a Vehicle on the protected route.

    d. Route locking: Setting / releasing routes as requested by the ATS commands. Each guideway element shall be reserved only for one route. To ensure a route is properly set, the related switches of a route and its overrun shall be set and locked in the correct position.

    e. Route Check

    f. Signal Clearing: Providing signal indications to the Train Operator

    g. Overrun Locking: To allow a Vehicle to stop close to a red signal or be able to Berth at the station platform, the ZC will extend the route reservation and thus the LMA past the stopping point associated with the signal or the platform. The Overrun will be released once the communicating Vehicle reports zero velocity at its destination.

    h. Traffic Locking. If an Interlocking is co-located with one or more street traffic signals, the CBTC System shall integrate with the traffic signal controller(s) such that a route is not reserved through the Interlocking associated with the integrated traffic signal(s) until the traffic signal controller(s) have given a permissive indication to the phase aligned with the Vehicle's requested movement, and such that the street traffic signal does not change phases until the route reservation overlapping with the street intersection has been released.

    i. Time/Approach Locking

    j. Switch Control: Automatically commanding switch moves based on route commands (Automatic Routing) and Moving switches manually following Transportation Controller commands.

    k. Switch Correspondence & Indication,

    l. All necessary data communication

5. The Contractor shall determine the existing functionality for each Interlocking and duplicate each Interlocking's existing functionality via the VOBCs, the Zone Controller and Object Controller associated with the Interlocking.

6. Interlocking functionalities shall apply to:

    a. CBTC-equipped Trains

    b. CBTC-equipped Trains with onboard Equipment or communication failures.

c. Heritage Vehicles

d. Maintenance Vehicles using the trackway (e.g., hi-railers)

7. Contractor shall submit a CBTC Interlocking Rules Specification [CDRL] as part of the System Design Documents.

16.3.1.3 COUPLING AND UNCOUPLING

1. The CBTC System shall provide ATP protected manual coupling and uncoupling of Trains anywhere in CBTC Territory as defined in Section 2.2.2 (CBTC Territory).

    a. Manual coupling and uncoupling initiation shall involve the Transportation Controller giving or confirming commands via the ATS user interface.

    b. In the absence of a coupling command from the Transportation Controller, the CBTC System shall stop Trains from getting closer than a specified minimum distance, which Contractor shall determine during System design as part of a safe train separation model.

    c. Upon the coupling or uncoupling command, the System shall reserve sections of track on either side of the coupling or uncoupling activity so that other Trains are safely separated from the activity, while allowing the Trains involved in the activity to come into contact with each other.

    d. The CBTC System shall remove the reservation only after the coupling or uncoupling is complete and after confirmation by the Transportation Controller.

    e. Once coupling / uncoupling indication is displayed on the TOD of the active train, the Train Operator shall initiate coupling or uncoupling of Trains in ATPM mode (in ATO or UTO Territory) or Street mode (in Street Territory).

    f. The CBTC System shall communicate coupling and uncoupling process status to the Train Operators on both Trains involved in the coupling maneuver.

    g. The CBTC System shall not permit coupling of two Trains which would result in a Consist length exceeding four cars.

    h. After coupling, the CBTC System shall:

        i. Automatically update the Consist length and shall display the new Consist length on the TOD.

        ii. Automatically update the Consist ID and Train ID to the Consist ID and Train ID of the Active Cab train.

    i. The CBTC System shall allow the Train Operator to manually input the Consist ID into the CBTC System.

    j. The CBTC System shall automatically update the new Consist ID in the ATS display.

    k. CBTC System shall communicate coupling and decoupling and changes in Consist/Block ID to Third-Party Systems as required for integration.

    l. Once coupled, the Train shall immediately function in any of the allowed CBTC modes.

    m. After uncoupling, each of the two Trains shall:

i. Automatically update the Consist length of each Train and display that information on the TOD.

ii. Have different Consist IDs and Train IDs automatically assigned to each Train by the CBTC System according to the requirements in Section 17.3.3.1 (Train Tracking Information).

iii. Immediately function in any of the allowed CBTC modes.

16.3.1.4 INTERLOCKING LOCAL CONTROL PANEL (LCP)

1. Contractor shall design and supply Local Control Panels as alternate means for operations staff present at the Junction to locally operate the following Interlockings:
    a. 4th & King
    b. Duboce & Church
    c. West Portal Ave & Ulloa
    d. St. Francis Circle (Sloat, Junipero Serra, St. Francis, Portola, and West Portal Ave)
2. Contractor shall, with input from SFMTA, include the locations where the LCPs will be installed in the vicinity at each specified Junction as part of the System Design Documents.
3. All LCP locations shall have line of sight to all of the approaches to the Junction they manage.
4. The LCP provided by Contractor shall, at a minimum:
    a. Perform switch maneuvers, and
    b. Perform route setting through the Interlocking
5. Contractor shall propose any additional functions that could be provided by the LCP during the Design Phase.
6. The LCP shall be operable in the event that communications between the Vehicle and the wayside or between the Control Center and the Interlocking are disrupted.
7. The control and handover requirements between the Control Center and Local Control Panels are specified in Section 17 (ATS Functions).
8. The LCP shall include physical security to guard against tampering and vandalism as described in Section 6.4.2 (Physical Security).

16.3.1.5 TRAIN DEPART LOCAL CONTROL CONSOLE

1. The CBTC System shall transfer local control from the Control Center to a Train Depart Local Control Console on the platform for the purposes of enabling on-site operations staff to issue depart commands to Trains locally during special events.
2. Contractor shall supply Train Depart Local Control Consoles to allow Trains to depart, which will be installed on station platforms at the following stations:
    a. King St & 2nd St (Ballpark).
    b. UCSF / Chase Center.

c. Embarcadero

d. Chinatown

3. Contractor shall include the exact locations of these Train Depart Local Control Consoles and associated signals (within the listed stations) to SFMTA in the System Design Documents. SFMTA will review and approve (or adjust) these locations during the Design Phase.

4. Contractor shall design for a wayside signal to be provided at both ends of each surface platform to indicate movement authority for Trains departing the platform in either direction.

5. Contractor shall design for two wayside signals to be placed back-to-back in the center of each surface platform to allow for double Berthing at these platforms.

6. The Train Depart Local Control feature shall function for departures in both directions at each platform to support reverse running operations.

7. The pushbutton console shall require remote activation from the Control Center ATS workstations to function, and it shall cease functioning when deactivated by the Transportation Controller using an ATS GUI command.

8. Contractor shall configure the pushbutton console to be time-activated, such that activation from the Control Center will initiate a Configurable time during which the pushbutton console will be active, and the pushbutton console will be automatically deactivated when that time has expired.

9. In ATO Territory, when the pushbutton console is active, Trains shall automatically depart after the pushbutton is pressed with no further user input.

10. In Street Territory, when the pushbutton console is active, Trains shall be given movement authority to depart and the platform signals shall display the appropriate permissive indications after the pushbutton is pressed with no further user input.

11. The pushbutton console shall indicate to the inspector on the platform that the Train received movement authority from the CBTC System to depart the station.

12. The pushbutton console shall indicate to the inspector on the platform that train departure local command has been accepted by the CBTC System.

13. The CBTC System shall indicate to the Train Operator that Train received movement authority from the CBTC System to depart.

14. Contractor shall provide the procedure to activate the pushbutton console from the platform in the O&M manuals submitted to SFMTA.

15. The Control Center ATS workstations shall have override activation and de-activation of the pushbutton console.

16.3.1.6 AUTOMATIC TURNBACK CONSOLE

1. Contractor shall supply four consoles, for both Embarcadero Westbound and Eastbound platforms, and both Chinatown platforms, to allow the Train Operator to activate the Automatic Turnback function for the Muni Metro Turnback (MMT) facility and the Central Subway tail tracks, as specified in Section 22.3.1 (Subway Locations).

2. The Automatic Turnback Console shall require remote activation from the Control Center ATS workstations to function.

3. The Automatic Turnback Console shall cease functioning when deactivated by the Transportation Controller using an ATS GUI command.

16.3.1.7 EMERGENCY STOP BUTTONS

1. Each Control Center shall be equipped with three physical Emergency Stop Buttons:

    a. A Market Street Emergency Stop Button that when activated will cause all Trains in ATO and UTO Territory in the Market Street Subway to activate full-service brake to a stop.

    b. A Central Subway Emergency Stop Button that when activated will cause all Trains in ATO and UTO Territory in the Central Subway to activate full-service brake to a stop.

    c. An MMT Emergency Stop Button that when activated will cause all UTO Trains in the Market Street Subway to activate full-service brake to a stop.

2. Contractor shall supply the Emergency Stop Buttons as specified in Section 27.7.3 (Workstations).

3. Contractor shall include plans and procedures for installation of the Emergency Stop Buttons in both Control Centers in the System Design Documents and the Construction Documents.

4. Contractor shall design the Emergency Stop Buttons to be installed next to the Transportation Controllers' ATS workstations.

5. The Emergency Stop Buttons shall be physically secured when the Control Center is not staffed as specified in Section 6.4.2 (Physical Security).

16.3.1.8 BLUE LIGHT SYSTEM

1. The CBTC System shall design and supply a functional interface with the existing Blue Light System as specified in Section 17 (ATS Functions).

2. When activated, the Blue Light System shall annunciate an alarm in the active Control Center and shall automatically reduce the speed of the Trains approaching the location where the Blue Light System has been activated.

3. The reduced speed limit associated with an active Blue Light System shall be Configurable by SFMTA.

16.3.1.9 TEMPORARY SPEED RESTRICTIONS

1. The CBTC System shall include a feature by which Transportation Controllers can set and remove Temporary Speed Restrictions (TSR), and define the section(s) of track for which the TSR is active (the “TSR Zone”), from their ATS workstations.

2. TSR Zones shall be Configurable via the ATS GUI to any length between the minimum size and the entire guideway.

3. The minimum TSR Zone size shall be no greater than 20 ft.

4. Once set, a Temporary Speed Restriction shall apply to all CBTC equipped Trains operating in the TSR Zone.

5. A TSR shall apply to a Train when the Train front crosses into the TSR Zone

6. A TSR shall no longer apply to the Train once Train rear has cleared the TSR Zone.

7. The TSR shall be Configurable via the ATS GUI as described in Section 19.7 (Speed Enforcement/Overspeed Warning).

8. The entered TSR shall factor into the maximum operating speed calculation as described in Section 19.7 (Speed Enforcement/Overspeed Warning).

9. The CBTC System shall include an ATS GUI command which modifies the track section(s) included in the TSR Zone for an active TSR.

10. The CBTC System shall include an ATS GUI command which modifies the speed limit for an active TSR without requiring the Transportation Controller to remove the TSR and establish a new one.

11. The CBTC System shall store each active TSR in a database or other memory such that all active Temporary Speed Restrictions can be automatically restored in the event of a CBTC System restart or Control Center switchover.

16.3.1.10 WORKER PROTECTION

1. The CBTC System shall include a roadway worker protection system that complies with CPUC GO-175A, other applicable CPUC regulations, FTA regulations, and SFMTA Roadway Worker Protection (RWP) rules.

2. The CBTC System shall track and report the location of maintenance crews by means of wireless wearable devices while the crews are in CBTC Territory. This device will use GPS signals on the surface and Contractor's GPS emulation system in the subways. The devices will communicate using the 5G radios and the DCS.

3. Contractor shall supply wireless portable devices that shall communicate with the central server using the 5G radios and DCS.

4. The central server shall interface directly with the ATS for the purpose of establishing a Work Zone.

    a. The portable devices shall have a minimum positional accuracy of +/- 20 ft.

    b. The Maintenance crew will place the portable devices at the start and end of the Work Zone and activate the devices. Once the devices are activated, the CBTC System shall detect the corresponding Work Zone and prompt the Transportation Controller for activation.

    c. Once the Work Zone section is established the CBTC System shall require activation from the Transportation Controllers at the Control Center via ATS command.

    d. The portable devices shall report which track (of a double track) the device is placed on such that their activation establishes a Work Zone on only one of the two parallel tracks.

5. The wireless wearable devices and wireless portable devices shall communicate with the CBTC System directly.

6. The wireless wearable devices and wireless portable devices shall not require a portable base station or any other device in order to operate.

7. The ATS shall include functionality enabling the Transportation Controllers using the ATS GUI to:

    a. Establish a Work Zone and define its boundaries in advance without using the wireless devices

    b. Store inactive Work Zones to be activated in the future, and

    c. Delete stored Work Zones from memory.

    d. Activate and deactivate Work Zones (both stored Work Zones and Work Zones established by wireless devices)

    e. Resize a Work Zone without the ATS subsystem requiring the removal and reinstatement of the existing Work Zone.

    f. Adjust Train speeds through the Work Zone

    g. Prevent all Trains from entering the Work Zone.

8. Stored Work Zones shall be able to be reused multiple times until deleted (for example if a construction crew is working at the same location multiple days in a row, the Transportation Controller can keep reusing the same Work Zone).

9. After activation, the CBTC System shall enforce the Work Zone regardless of the status of the wireless devices used to establish the Work Zone.

10. The CBTC System shall be able to manage at least 25 active Work Zones simultaneously and store at least 500 inactive Work Zones in memory.

11. The CBTC System shall provide ATP protection for an active Work Zone and graphically represent it to the Transportation Controllers on the ATS GUI.

12. The CBTC System shall create two Temporary Speed Restrictions (TSRs) for each active Work Zone:

    a. A TSR on the adjacent area, preceding the active Work Zone in both directions.

    b. A TSR in effect in the active Work Zone.

13. The CBTC system onboard Trains approaching a Work Zone shall indicate on the TOD the train's distance from the Work Zone and the maximum speed allowed in the Work Zone.

14. Work Zones shall be classified as zones with UTO and ATO Mode Disallowed. The System shall apply full-service brakes to stop UTO and ATO Trains before they reach the Work Zone.

15. If an ATS command has been issued closing a Work Zone to Train traffic, the ZC shall treat the border of the Work Zone as an obstruction to movement authority for all approaching Trains.

16. The CBTC System shall activate an audible and visible warning onto the wireless wearable devices when a Train is approaching the Work Zone.

17. The CBTC System shall activate an audible and visible alarm in the event a Train enters a Work Zone where Trains are prohibited from entering. The alarm shall notify to:

a. The Transportation Controller ATS GUIs in the Control Centers

b. In the operating cab of the train

c. The wearable devices held by the roadway workers. This alarm shall have a different tone pattern from the alarm given to indicate an approaching train.

18. Contractor shall submit a CBTC Worker Protection System Design document [CDRL] as part of the System Design Documents.

16.3.1.11 ENERGY SAVING

1. The CBTC System shall have an Energy Saving function to optimize energy consumption by modifying Train operation and performance parameters.

2. Energy Saving parameters shall automatically be adjusted based on timetable database inputs.

3. The CBTC System shall have Configurable Energy Saving functions to increase or reduce energy saving efforts during revenue hours.

16.3.2 DATA COMMUNICATION SYSTEM

1. Contractor shall design and supply a Data Communication System which includes all communication elements required for the CBTC System in compliance as specified in this Section and Section 26 (Communications).

2. Contractor shall maximize the use of existing SFMTA communications infrastructure as described in Section 9 (SFMTA Furnished Items).

3. Contractor shall design and supply a redundant and resilient communication link to ensure Availability and Reliability of the CBTC System as described in Section 30 (Reliability, Availability, and Maintainability).

16.3.3 CENTRALIZED MAINTENANCE MANAGEMENT SYSTEM

1. The CBTC System shall include an Asset Management System (AMS) to receive and manage real time indications, to log events, alarms, and other outputs from central, wayside and Vehicle onboard systems.

2. Contractor shall Furnish and supervise the installation of AMS terminals at TMC and OCC Control Centers, 700 Pennsylvania, Muni Metro East (Yard) (MME) and Green Division facilities to display real time information of the operational status of all CBTC System components.

3. The requirements for the Asset Management System are specified in Section 20 (Maintenance and Diagnostic Functions).

16.3.4 MASTER CLOCK

1. The CBTC System shall have a master clock.

2. The master clock shall use the Network Time Protocol (NTP) to communicate to other SFMTA systems.

3. Contractor shall submit a CBTC Master Clock Design document [CDRL] as part of the System Design Documents.

16.3.5 THIRD-PARTY SYSTEM INTERFACES

1. The CBTC System shall have a functional interface with the following Third-Party Systems:
    a. Real- Time Predictions (currently Umo IQ)
    b. Platform Passenger Information (currently Penta)
    c. Onboard Passenger Information (currently Televic)
    d. Enterprise Asset Management System (EAMS) (currently Infor)
    e. Computer Aided Dispatch Automatic Vehicle Location (CAD/AVL) System (currently Conduent OrbCAD)
    f. Scheduling system (currently Trapeze)
    g. Control Center videowall system
    h. Intrusion detection System
    i. Supervisory Control and Data Acquisition (SCADA)
2. External interfaces requirements are specified in Section 28 (Interface Requirements Specifications).

16.4 SYSTEM PERFORMANCE

1. Contractor shall design the CBTC System for a maximum Vehicle speed of 50 MPH.
2. The CBTC System shall support bidirectional Trains operating in mixed fleets with variable Consists of 1 to 4 cars.
3. The CBTC System shall achieve the Performance Requirements specified in Section 30 and Appendix I.
4. Contractor shall demonstrate performance of the CBTC System on each track and on both normal and reverse directions and as specified in Section 30 (Reliability, Availability, and Maintainability).

16.4.1 SYSTEM CAPACITY IN THE MARKET STREET SUBWAY

1. The SFMTA will run Trains 60 seconds apart in the Market Street Subway. The CBTC System shall support minimum operational headways of 60 seconds or less in the Market Street Subway.
2. The Contractor shall demonstrate, during the RAM Demonstration, a maximum throughput of at least 48 trains per hour at Embarcadero Station, as measured by the number of Trains observed traveling through that station in revenue service in both directions during a three-hour peak period under typical service conditions.
3. The CBTC System shall include a feature by which SFMTA can Configure the minimum operational headways to a value greater than the minimum operational headway specified in this Section 16.4.1.
4. This headway configuration feature shall allow SFMTA to specify headways for specific days and specific times of day, or indefinitely.

16.4.2 CBTC SYSTEM PERFORMANCE SIMULATION

1. During design, Contractor shall use a System Performance simulator to validate schedule and headway performance of the System under variable operating conditions.

2. Contractor shall test multiple scenarios using the System Performance simulation which together reflect the majority of operating conditions likely to be encountered in revenue service.

3. SFMTA shall review and approve the list of test scenarios prior to testing.

4. Contractor shall submit a detailed list of variable inputs and variability ranges for SFMTA approval prior to running the simulation.

5. This list shall include at least the following parameters (Contractor may suggest additional parameters or metrics) to measure System Performance:

    a. Dwell Time at each platform.

    b. Delays to Train arrivals at portals.

    c. Change in Train arrival order at portals.

    d. Variation in Train speed in tunnel sections.

    e. Reversal of Train travel direction event (turn backs) occurring.

    f. Failure of Trains in tunnel sections or at platforms resulting in delays and Bunching.

    g. Delay at Junctions due to conflicting trains.

    h. Variable ordering of Trains allowed through a contested Junction.

6. The simulation shall use a timetable supplied by SFMTA.

7. The simulation shall produce timetable schedule-based and headway-based results.

8. The performance simulator shall have as its output:

    a. List of the inputs used for each iteration of the simulation.

    b. Result of the simulation run for each set of inputs, with details of the calculated results for each step of the simulation.

    c. Graphical report output to allow for comparison between different simulation variables.

    d. Calculated value for wheel start to wheel stop for each station-to-station segment.

    e. Calculated platform reoccupation time

    f. A table with timestamps and location information for each Vehicle with a user-adjusted time resolution

9. Stopped Delay and General Delay (Expected TT - Actual TT)

10. Contractor shall submit the output results from the simulator in a common, non-proprietary format such as a CSV, text or Excel file.

11. The simulator shall have a mode to accept manually selected simulation values as inputs.

12. Contractor shall submit a CBTC System Performance Simulation Report [CDRL] with the simulation results as part of the Preliminary Design Review package.

13. Contractor shall resubmit the CBTC System Performance Simulation Report as part of the Final Design Review package.

14. If any simulation parameters, scenarios, assumptions, conditions or inputs have changed as a result of the final design process that would affect the outcome of the simulation, Contractor shall rerun the simulation and update the CBTC System Performance Simulation Report with the updated results. If Contractor asserts no significant changes have been made, Contractor need not update the CBTC System Performance Simulation Report before resubmittal.

15. In the CBTC Performance Simulation Report, Contractor shall report whether the SFMTA's performance requirements were met during each scenario.

16. The CBTC System Performance Simulation Report shall include statements predicting, based on the simulation results, under which actual operating conditions the minimum operational headway and maximum throughput specified in Section 16.4.1 will be met, and under which actual operating conditions the performance requirements will not be met.

16.5 SYSTEM ARCHITECTURE, FUNCTIONS AND PERFORMANCE CDRLS

Table 16-19: System Architecture, Functions and Performance CDRL Table

CDRL #	CDRL Title
16.01	CBTC System Architecture
16.02	CBTC System Functional Specification
16.03	CBTC Interlocking Rules Specification
16.04	CBTC Worker Protection System Description
16.05	CBTC Master Clock Design
16.06	CBTC System Performance Simulation Report

17 AUTOMATIC TRAIN SUPERVISION (ATS) FUNCTIONS

17.1 PURPOSE

1. This Section specifies the requirements for the CBTC Automatic Train Supervision (ATS) subsystem.

17.2 GENERAL

1. Contractor shall design, Furnish, test and commission an ATS subsystem with client workstations to be operated from both the TMC primary Control Center and in the OCC backup Control Center.

2. The ATS subsystem shall have a functional human-machine interface between the CBTC System and the Transportation Controllers.

3. The ATS subsystem shall manage, monitor, control, and report on all CBTC-related control functions and statuses for all rail operations, including DCS hardware, Zone Controllers, Object Controllers, Track elements (e.g., transponders) and onboard hardware (i.e., on LRVs, Heritage Vehicles and non-revenue rail vehicles), in CBTC Territory.

4. The ATS subsystem shall utilize computer-based graphical user interfaces (GUIs) to control and monitor Train movements and operations by the Transportation Controllers from dedicated ATS client workstations.

5. ATS Workstations and console furniture requirements are specified in Section 27 (Equipment Requirements).

6. The ATS subsystem shall provide Automatic Train Supervision for all Vehicles in CBTC Territory as described in Section 2.2.2 (CBTC Territory).

7. The ATS subsystem shall not require the Transportation Controller to perform any manual data input when a CBTC Train is initialized by the CBTC System.

8. The ATS GUI commands shall use both point devices (mouse clicks) and keyboard shortcuts.

9. The ATS subsystem shall not require Transportation Controllers to use a command line interface to issue any command that is necessary to perform their job functions. Command lines may be used for infrequent System Configuration commands.

10. Contractor shall submit the ATS Design Description Document [CDRL] for SFMTA approval at the Preliminary Design Review.

11. The ATS Design Description Document shall contain a detailed description of:

    a. ATS architecture

    b. ATS Hardware

    c. ATS functions

    d. ATS GUI

    e. ATS external interfaces

    f. ATS commands and symbols.

12. Contractor shall include the ATS Software Architecture [CDRL] containing the detailed description of all ATS Software as part of the System Design Documents.

13. Contractor shall submit a ATS Human Factors Analysis and Review Document [CDRL] at the Preliminary Design Review.

14. The ATS Human Factors Analysis and Review Document shall include:

    a. all track and control displays

    b. user interface mock-ups

    c. non-functional or static presentations.

15. Contractor shall review mock-up and non-functional presentations to SFMTA during Contractor's development of the ATS Human Factors Analysis and Review Document [CDRL] to gather input from SFMTA before submittal.

16. Contractor shall use SFMTA input and the ATS Human Factors Analysis and Review Document [CDRL] to develop the ATS design.

17. Contractor shall submit an Interface Control Document [ICD] for all external interfaces as part of the System Design Documents.

18. The Interface Control Document shall describe the interfaces and management processes to confirm these interfaces are designed, implemented and verified.

19. The alphanumeric identifiers available for Service Line Assignment shall be Configurable by SFMTA without requiring a Software update from Contractor each time information for a Service Line is updated or a new Service Line is added.

20. The ATS subsystem shall support one or two digit combinations of any letter of the alphabet or number (Examples: A, KT, 1, J2) as the alphanumeric identifier for a Service Line Assignment.

21. The ATS subsystem shall permit SFMTA to define multiple Service Patterns for the same Service Line through Configuration without requiring a Software update from Contractor each time information for a Service Line is updated or a new Service Line is added.

22. The ATS subsystem shall:

    a. Track, log and report all Vehicle movements in CBTC Territory.

    b. Display all Vehicles and their movements on computer graphic displays (line overview/tracking displays).

    c. Associate the tracking, logging, displaying, and reporting of all Train (revenue and non-revenue) movements by their assigned Schedule Block and Block ID where:

        i. Schedule Block identifies the line designation, day's Trips, crew info, and the Service Pattern (designated path, stations/stops and route alignments from origination to destination that is predetermined for the service) assigned for each Trip to be taken by the Consist for the day.

        ii. Block ID is a unique number associated with the Schedule Block. Only one Train may be associated with a Block ID at a given time.

    d. Display and log the following identifying information for Trains in CBTC Territory:

i. Consist ID / Block ID
ii. Number of LRVs in Consist
iii. Train ID
iv. Vehicle IDs (side numbers) for each LRV in Consist
v. Service Line Assignment (i.e., J, K, L, M, N, T, S, X)
vi. Service pattern
vii. Trip ID
viii. Train mode of operation as defined in Section 22.2 (Operating Modes)

e. Display and log Vehicle ID numbers for tracked Maintenance and Heritage Vehicles in CBTC Territory.

f. Store the Vehicle information in paragraph 16 (d) and (e) of this Section in memory so that in the event of an ATS subsystem failure and following a subsequent restart or the startup of the cold standby backup ATS subsystem, the ATS, restores the Vehicle IDs, assignments and identifying information to the correct Vehicles, within one minute after the ATS startup.

g. Interface with Interlockings via the associated Zone Controller and Object Controller for the purpose to:

i. Initiate, set, and cancel Vehicle routes.
ii. Receive confirmation of Vehicle routes.
iii. Control and receive status of switch positions and signal aspects.
iv. Set blocks of signals, switches, and routes.

h. Support the creation of lines starting from any stop, platform or terminal and ending at any stop, platform or terminal using any interlocking and switch identified in Figure 16-1, including manually operated switches.

i. Interface with the CBTC System for the control, management, and display of CBTC functions and operational messages and alarms.

j. Interface with CBTC System's Asset Management System (AMS) to acquire indications to populate the health and status messages and diagnostic alarms, and maintenance displays and their acknowledgement as specified in Section 20 (Maintenance and Diagnostic Functions).

k. Provide SFMTA staff access to the ATS subsystem through a mobile application. This access shall have ATS subsystem viewing mode thorough this mobile application as specified in Section 17.4 (ATS Mobile Viewer).

l. Implement Route management functions.

m. Implement Station bypass (skip stop), train hold functions.

n. Implement Schedule Management functions.

o. Implement Daily train reporting function.

p. Implement train regulation functions.

q. Include a function enabling Transportation Controllers to close sections of track. The CBTC System shall prevent CBTC equipped Vehicles from entering the closed area and prevent CBTC equipped Vehicles inside the closed area from moving.

r. Set, display, and remove Temporary Speed Restrictions as specified in Section 16.3.1.9 (Temporary Speed Restrictions).

s. Set, display, and remove Work Zones as specified in Section 16.3.1.10 (Worker Protection)

t. Prevent overloading of power and ventilation sections by restricting the number of Trains that can enter or operate in a defined power/ventilation section.

u. Interface with physical Emergency Stop Buttons, platform Local Control Panels and platform Train Depart Consoles as specified in Section 16.3.1 (Train Control and Supervision).

v. Interface with Third-Party Systems as specified in Section 28 (Interface Requirements Specifications).

w. Archive and timestamp all ATS events categorized as follows:

   i. all ATS commands and actions applied or executed manually or automatically

   ii. all Interlocking status and changes

   iii. all CBTC-driven status and changes

   iv. all health/diagnostics/alarms status and changes

   v. all System user logon/logoff.

x. Include Playback capability as specified in Section 21.2.4 (ATS Playback System).

y. Detect, log, and report faults and alarms.

17.3 ATS GRAPHICAL USER INTERFACE

1. The ATS subsystem shall have a Graphical User Interface (ATS GUI) that graphically portrays required information to the Transportation Controllers.

2. The ATS GUI shall have a combination of point and click interface and text-based interface features by which SFMTA Transportation Controllers will execute commands through drop down selection lists by selecting one, all, or a subset of list entries in a single command.

3. The ATS GUI shall have windows (new screen), dialog boxes, drop-down menus, go-to (navigational) buttons, expandable detail windows, mouse-over popup displays, and clickable objects as tools that interface with the ATS GUI displays to prompt, guide, select, apply, accept, and execute commands and requests.

4. The ATS GUI shall include keyboard shortcuts for common commands made by Transportation Controllers.

5. Contractor shall submit a list of commands using a keyboard shortcut within the ATS Design Description Document [CDRL] for SFMTA approval.

6. Where an input command to ATS is acknowledged by the GUI, and the actual implementation of the command requires additional time, the ATS GUI shall display a status indication to show the command is in progress.

a. The status indication shall remain present on the display until the commanded actions have been completed.

b. Once the command implementation has completed the status indication shall disappear from the display.

7. The ATS subsystem shall have additional confirmation prompts for Critical Commands as necessary to address Hazards identified in the Hazard Log. Critical Commands initiated by ATS require an added level of safety through requiring the Transportation Controller to confirm the initiated command to reduce the likelihood of a mistake or wrong implementation.

8. Contractor shall include the list of Critical Commands and the functional response in the ATS Design Description Document [CDRL] for SFMTA approval.

9. The ATS subsystem shall provide functionality for Transportation Controllers to project a predefined screen display onto the videowall.

    a. Contractor shall develop, with SFMTA input, a set of predetermined ATS screen display layouts used for projection on the TMC videowall. Contractor shall include this ATS Screen Displays for the Videowall document [CDRL] as part of the System Design Documents.

10. The ATS subsystem shall have a method for Transportation Controllers to select a screen to be printed in color or black and white.

11. The ATS GUI shall have a zoom function for Transportation Controllers to enlarge the line overview or tracking displays on the workstation GUI, and the display on the videowall system.

12. The zoom function of the ATS GUI shall zoom in and out of displays with proper and correct scaling using the mouse scroll-wheel.

13. The ATS GUI shall have a clear and readable display at any zoom level.

14. The Line Overview Display shall include input pointer dragging to relocate the field of view while zoomed in.

15. The display of the Line Overview image shall refresh with low latency and present a smooth movement of the field of view while being dragged.

16. Contractor shall develop a GUI Displays Description [CDRL] that details the graphical interface and command functions of the ATS subsystem in the System Design Phase.

17. Contractor shall include the GUI Displays Description in the Preliminary Design Review submittal for SFMTA approval.

18. The ATS GUI shall be a modern, web-based HMI with a streamlined look and feel designed using modern UX/UI methodologies for improved usability and efficiency in operations.

19. The ATS web-based application shall support the two most popular Windows-based browsers by market share (currently Google Chrome and Microsoft Edge). Contractor shall update its ATS web-based application as necessary throughout the Contract Term to meet this requirement.

20. The ATS web-based application shall not require any browser extensions, scripts, patches, custom browser builds, custom configurations, or plug-ins to function.

21. Until the end of the Contract Term, Contractor shall update its ATS web-based application so that it supports at least the two most recent browser major versions, and current (non-deprecated) APIs or libraries.

17.3.1 GUI MODES

1. The graphical interface shall have a viewing mode and a management mode.

2. The ATS subsystem viewing mode shall have viewing functionality for SFMTA users, for all GUI indications and displays.

3. The CBTC System shall prevent commands to control and manage the ATS System from being requested or executed while in viewing mode.

4. The ATS subsystem management mode shall provide the means for authorized users to issue commands to control and manage the ATS System.

5. The ATS subsystem shall include a feature by which SFMTA can set levels of authority for individual users without assistance from Contractor.

    a. The ATS subsystem GUI shall contract System access using two-factor authentication which shall include:

        i. A card reader, biometric scan function, or authenticator app

        ii. Username and password authentication.

    b. The username and password authentication shall comply with the cyber security specifications in Section 6.4.3 (Cyber Security).

    c. Contractor shall include the two-factor authentication system design in the System Design Documents.

6. The ATS subsystem shall limit which functions, commands, controls and views are visible and available based on the user's level of authority.

17.3.2 LINE AND TRAIN TRACKING DISPLAYS

1. The ATS subsystem GUI shall have line overview and train tracking displays with different, Configurable levels of train tracking data and with minimal display clutter at 100% zoom level in graphical Line Overview Displays on individual workstations and on the videowall.

17.3.2.1 LINE OVERVIEW DISPLAYS

1. The ATS Line Overview Display shall:

    a. Display a view of the entire CBTC Territory

    b. Display Vehicle movement data in real-time.

2. The ATS Line Overview Display shall include, but not be limited to the following information:

    a. Vehicle movements and direction

    b. Consist ID / Block ID for each Train

    c. Service Line Assignment for each Train (e.g., J, K, L, M, N, T, S) (declutterable)

d. Service pattern / destination for each Train (declutterable)

e. CBTC Operating mode for each Train

f. Work zones and Temporary Speed Restrictions in place (declutterable)

g. Manual Route Reservations. (declutterable)

h. Signal Aspects (declutterable)

i. Switch positions and states (unlocked/locked/manual mode).

j. Limit of Movement Authority (LMA) or proportional track block segment reservation (declutterable), or approved equal

k. Route selected. (declutterable)

l. Dwell Time Display (declutterable)

m. LRV Door Status Display (declutterable)

n. ATO Train Override Status

o. Activation of Emergency Stop Button

p. Status of Wayside assets. (declutterable)

q. Status of traction power. (declutterable)

r. Traction Power and Ventilation section limits (declutterable)

s. Maximum number of Trains allowed in Traction Power or Tunnel Ventilation section (declutterable)

3. For items noted with (declutterable), the ATS Line Overview Display shall have a selection function that can remove this information from the display.

4. Contractor shall describe the information to be included in the Line Overview Display [CDRL] in the System Design Documents.

17.3.3 TRAIN TRACKING DISPLAYS

1. The ATS subsystem shall have train tracking displays that track movement of Vehicles in CBTC Territory.

2. The train tracking displays for each individual Service Line shall show terminal to terminal details and contain more train tracking information and details than the full line overview.

3. Contractor shall describe the information to be included in the train tracking display [CDRL] in the System Design Documents.

17.3.3.1 TRAIN TRACKING INFORMATION

1. The ATS subsystem shall track, log and display the following information for each Train in CBTC Territory:

    a. Train ID

b. Vehicle IDs (side numbers) for each LRV in Consist

c. Number of cars in Consist

d. Consist ID or Block ID matched to schedule/ CAD/AVL system /Trapeze

e. Service Line Assignment (e.g., J, K, L, M, N, T, S)

f. Service pattern / destination

g. Trip ID

h. Positioning in latitude/longitude in addition to linear referencing

i. Indication of Train's mode of operation (e.g., CBTC mode, manual), or condition that limits its operational capability

2. The ATS train tracking function shall also track, log and display the position and Vehicle ID of Heritage Vehicles and Maintenance Vehicles.

3. The ATS train tracking display shall display the following information, in addition to the information in paragraphs (1) and (2) in this Section 17.3.3.1:

a. LRV Door Status Display

b. If the Train is stopped at a platform or stop, the Dwell Time remaining

c. If the Train is at a terminal, its next departure time according to the train regulation (Schedule or Headway) adherence feature.

d. Variation from headway or from schedule as described in Section 17.5.1.4.

4. The ATS subsystem shall automatically assign Consist IDs that are identical to the Block ID assigned to the Active Cab in the CAD/AVL system.

a. If unable to obtain a Block ID from the CAD/AVL system, the ATS subsystem shall automatically assign the Train a Consist ID from a set of IDs reserved for unassigned Trains.

b. The ATS subsystem shall have a feature which re-synchronizes an unassigned Train's Consist ID with the CAD/AVL system Block ID when it becomes available.

5. The ATS subsystem shall track movement of every Vehicle from the point at which it enters CBTC Territory until it has left CBTC Territory.

17.3.3.2 ROUTE TRACKING

1. The ATS subsystem shall track the routing of the Vehicles and log (with available open standard access) the details of routing, including and not limited to:

a. A Vehicle's assigned/reassigned Service Pattern.

b. Time and location where Service Pattern change was applied, and reason for route change

c. Train's origination/destination change

d. Travel times and Trip performance by route (actual versus scheduled) from station to station, terminal to terminal

2. The ATS subsystem shall display a Train's Service Pattern graphically upon selection of the Vehicle's icon on the ATS tracking screen as a line that is superimposed over the track/guideway extending from the tip of the Vehicle's icon in the direction of travel to its destination.

17.3.4 INCIDENT MITIGATION FUNCTIONS

1. The ATS subsystem shall include Software tools and functionality, called Incident Mitigation Functions, that allow Transportation Controllers to mitigate operational impacts to rail service during disruptive events that cause anticipated and unanticipated delays.

2. These Incident Mitigation Functions shall alter the scheduled arrival and departure times loaded into the System and cause the train regulation functions to adapt accordingly.

3. The System shall include Incident Mitigation Functions which enable the user to:

    a. Setup turnbacks, where a new outer terminal is established short of the end of the line, to be used in the event the tracks are blocked. Outer terminals are defined as the terminals that are outside of the downtown area (e.g. Sunnydale, Balboa Park, Ocean Beach, Zoo).

        i. These turnbacks shall coincide with crossovers, wyes and other locations where a Train can be turned.

        ii. The truncated service shall run between the downtown terminal (e.g. Embarcadero, Chinatown, 4th and King) and the turnback location.

    b. Fleet signals

    c. Enforce or change order of Trains

    d. Establish an ad-hoc "shuttle" service that runs in a loop between two stops/platforms and serves all platforms/stops in between. This feature may limit the selection to predefined platform/stop pairs identified during the Design Phase. The System shall compute the headway of this service based on the number of vehicles assigned to it.

    e. Reassign Trains to other work assignment blocks (and support Train reassignment while in service based on real-time assignment update from CAD/AVL system)

    f. Setup service diversions

    g. Cancel future Trips not yet in progress.

    h. Flex the schedule using a user-entered "schedule offset" which shifts the entire schedule for a line by the number of minutes entered. Used when it is recognized that the line cannot recover enough time to get back on schedule.

    i. Setup single track operations

    j. Hold Trains at a platform for a user-Configurable length of time, or indefinitely. The System shall have the option to hold all Trains at a platform, a specific Train, or the next X Trains.

4. The System shall communicate these changes to the CAD/AVL system and align the Block, Trip and Service Line identifiers with the CAD/AVL system for performance logging and customer information purposes as described in Section 28.4.4 (Computer-Aided Dispatch (OrbCAD)).

17.4 ATS MOBILE VIEWER

1. Contractor shall provide a secure URL viewable on mobile and desktop browsers ("Mobile Viewer") that is accessible on Apple, Android, and Windows devices for SFMTA staff to view the ATS.

2. The Mobile Viewer shall have view capabilities only.

3. The Mobile Viewer GUI shall have Line Overview and Train Tracking views as specified in Section 17.3.2 and 17.3.3.

4. Contractor shall describe the details of the Mobile Viewer GUI layout in the ATS Design Description Document [CDRL] and submit to SFMTA for approval as part of Preliminary Design Review.

5. The operational condition and status of the Mobile Viewer and connection status of the interface between the ATS subsystem and the Mobile Viewer shall not disrupt nor have any impact on the performance or Availability of the ATS System.

6. Contractor shall secure the Mobile Viewer in accordance with SFMTA cybersecurity requirements as specified in Section 6.4.3 (Cyber Security), SFMTA policies, and Codes and Standards as specified in Section 7.

7. The Mobile Viewer shall require a login with MFA to verify viewers are authorized SFMTA personnel.

8. Contractor shall include the ATS Mobile Viewer Design Description [CDRL], containing the detail design of the functions, Software and Hardware architecture, and interfaces, in the System Design Documents.

17.5 ATS FUNCTIONS

17.5.1 ROUTE SETTING FUNCTIONS

1. Contractor shall design and implement the following routing modes for each integrated Zone/Object Controller Interlocking:

    a. Automatic Route Setting (ARS)

    b. Manual Route Setting (MRS)

    c. Manual Route Authorization (MRA)

2. The System shall provide all Route Setting Functions described in this Section to Heritage Vehicles.

3. Maintenance Vehicles shall use Manual Route Reservations to reserve routes through Interlockings.

4. Automatic Route Setting shall design and supply the route setting mode to set routes automatically based on the Vehicle's Trip assignment information.

5. The ARS shall utilize the Vehicle's Schedule Block, Line Designation, Service Pattern and Consist information to set routes.

6. The ARS mode shall automatically set routes for a Train that clears a requested signal without a reduction in the Train's speed profile.

7. Contractor shall submit, as part of the System Design Documents for SFMTA approval, the location, or initiation point, in advance of a signal where each signal route request gets automatically initiated.

8. For every signal, the ATS subsystem shall have an Early Control Time (ECT) function to allow an authorized ATS user to enter a value for the offset delay (in seconds) from when the Vehicle reaches the route request initiation point to when the signal is requested by the System. For example, if delay is set to 0 (default), the signal is requested immediately when Vehicle reaches the initiation point. If ECT offset delay is set to 5 seconds, the signal is requested 5 seconds after Vehicle reaches the initiation point.

    a. The ECT delay value shall be a user-Configurable parameter.

    b. The ECT delay value shall be retained after any restart of the ATS server such that it does not have to be re-entered after a restart.

9. The CBTC System shall set ARS mode as the default route setting mode at all integrated Zone/Object Controller Interlockings.

10. The ARS shall set routes based on required headway and schedule information, including the deadhead from the yard to the first station in-service, the in-service routing from terminal to terminal, and the return routing from the terminal back to the yard, without controller intervention.

11. The ARS shall automatically set routes according to the Trip's Service Pattern or path of travel that includes the non Revenue Service transit of the Vehicle from the yard to the first station in-service, the in-service routing from terminal to terminal, and the return routing from the terminal back to the yard, without ATS-user (Transportation Controller) intervention unless the requested route is restricted or when a Vehicle or failure Incident impacts service.

12. If a condition exists that prevents the execution of an ARS-requested route, the ATS subsystem shall continue the route request while the condition exists or when the route request is manually canceled by the Transportation Controller.

13. Manually canceling an ARS-requested route while the Interlocking is in ARS mode shall halt the automatic retry process.

14. Canceling an ARS-requested route shall not place the Interlocking in MRS mode.

15. The ATS shall include a routing mode selection function which allows the Transportation Controller to individually set either ARS or MRS mode for every Interlocking in CBTC Territory.

16. When MRS mode is set for an Interlocking, the CBTC System shall disable the ARS mode to enable the Transportation Controllers to manually set, fleet, and cancel routes.

17. The CBTC System shall fleet the signal only when the Interlocking is in MRS mode.

18. Transportation Controllers shall cancel fleeted signals prior to setting those signals into ARS mode.

19. The System shall include a Manual Route Authorization (MRA) function as specified in Section 19.

20. The ATS GUI shall differentiate the display of requested and locked routes.

21. The ATS GUI shall differentiate the display of routes based on the routing mode.

22. The ATS System shall include a feature that enables Transportation Controllers to quickly modify the Service Pattern for a single Train's upcoming Trips. The feature shall enable the user to modify:

    a. A single Trip,

    b. Multiple Trips, and

    c. All future Trips that are part of one or more Schedule Blocks.

17.5.1.1 ATS RESTRICTED ROUTE CONTROL FUNCTION

1. The ATS shall have a Restricted Route Control function that enables the Transportation Controllers to set and restrict a route from being automatically initiated by the ARS.

2. The ATS subsystem Restricted Route Control function shall allow Transportation Controllers to remove restricted route settings.

3. The ATS GUI shall have an indication next to the signal on the tracking displays to indicate that a restricted route has been set.

4. Once a restricted route is set, the ATS subsystem shall retain the setting of the restricted route even after the ATS subsystem is restarted.

5. The ATS subsystem shall display a warning message to the Transportation Controller if the ARS encounters a route request for a restricted route.

6. The ATS subsystem shall accompany the warning message with a user prompt for the Transportation Controller to either cancel the impending restricted route request or to accept and confirm the restricted route to be requested.

7. If the Transportation Controller cancels an impending restricted route request via the user-prompt, the ATS subsystem shall cancel it.

8. To move Vehicle after an ARS impending restricted route cancellation, the ATS subsystem shall allow a Transportation Controller to modify the Trip to take an alternate Service Pattern or to switch the route setting mode to MRS mode so an alternate route can be set manually as an optional function.

9. In MRS mode, the ATS subsystem shall ignore the restricted route settings.

10. The ATS subsystem shall log all restricted route control settings and removals by ATS users.

17.5.1.2 ATS AUTOMATIC REROUTE FUNCTION

1. The ATS subsystem shall have an automatic reroute function which assigns Trains alternate routing consistent with their Trip assignment when a blockage to the guideway is reported to the ATS, if alternate routing is available.

2. The ATS subsystem shall request confirmation from the Transportation Controller before applying the automatic reroute.

3. The ATS subsystem shall enforce the automatic reroute until the Transportation Controller cancels the automatic reroute.

4. The automatic reroute function shall function as a temporary override to the Train's original routing based on its Trip assignment, so that the Train returns to the original routing and makes its originally planned/scheduled stops after it completes the assigned reroute.

5. The automatic reroute shall function at all Interlockings.

6. When an automatic reroute is in effect, the skip-stop, stop now, train/station hold command, and train regulation functions shall remain applicable to a rerouted Train during and after it is rerouted.

7. The ATS GUI shall uniquely identify and display a route that has been set by the automatic reroute function.

8. The ATCS shall communicate the automatic reroute and associated information such as routing, timetable, travel times, distances, to Third-Party Systems.

17.5.1.3 ATS JUNCTION MANAGEMENT FUNCTION

1. The ATS subsystem shall automatically resolve conflicts at Junctions such that the Vehicle movements result in the closest adherence to the timetable schedule and required headway.

2. The ATS subsystem shall have a Junction management function that Transportation Controllers use to select the following modes of operation:

    a. Following assigned schedule with compensation for Vehicle delayed past a threshold

    b. Strictly in order of assigned schedule

    c. First-come-first-served

    d. Based on manual prioritization as Vehicles approach Junctions

3. The ATS subsystem shall continue to regulate a Junction, per the selected Junction management mode, through closed tracks, platform holds, or any other ATS commands that impacts routing and timing of Vehicles.

17.5.1.4 ATS TRAIN REGULATION FUNCTION

1. The ATS subsystem shall have a train regulation function that automatically monitors and regulates the performance of the revenue Train service in relation to schedule and/or headway variance.

2. When the Train is operating in ATO or UTO mode, the function shall operate as an Automatic Train Regulation (ATR) function that uses the Automatic Train Operation functionality to achieve this regulation.

3. When the Train is operating in Street Mode, the Train Operator must perform any actions suggested by the train regulation function, so the System shall instead indicate the necessary actions to the Train Operator using the TOD.

4. The train regulation function shall support both a schedule regulation mode and a headway regulation mode. Modes are selectable by line between two times of day as determined by SFMTA.

5. The train regulation function shall regulate Train movements based upon the Schedule Blocks assigned to each Train, relative Train locations, scheduled and actual headways between Trains, and regulation parameters input by the Transportation Controllers.

6. Schedule and headway control for CBTC-equipped Trains shall use Dwell Time variance and control of Train performance through a pacing speed value to the next platform/timepoint.

7. The ATS subsystem shall measure Train progress along the track at regulation points composed of all the stations or stops in the Train's Service Pattern.

8. The ATS subsystem shall regulate Trains (accelerated or delayed) according to the variance to schedule and headway as recorded at the last regulation point up to the next regulation point.

9. When train regulation is enabled, the train regulation function shall regulate Trains using the following parameters:

    a. Platform specific parameters such as minimum Dwell Time, nominal Dwell Time, maximum Dwell Time, timed hold

    b. Anti-bunching thresholds

    c. Earliest control time settings

    d. Travel time between stations by setting the Train's recommended pacing speed value to be applied up to the next platform

    e. Regulation thresholds such as maximum Train delay, maximum headway deviation with respect to the Train ahead and the Train behind the regulated Train

10. The train regulation parameters shall be Configurable by authorized SFMTA personnel.

11. The Schedule Regulation Mode of the train regulation function shall manage the movement of each revenue Train in the System to meet assigned schedule arrival and departure times at each timepoint along the route assigned to that Train.

12. The Headway Regulation Mode of the train regulation function shall maintain the specified headway between individual Trains operating on the same Service Line.

13. The ATS shall include a command for Transportation Controllers to set the headway parameter to be used by the Train regulation function in Headway Regulation Mode for each Service Line.

14. The train regulation function shall monitor the Train delays and out-of-headways and generate an alarm when a delay exceeds thresholds specified in the System design.

15. The train regulation function delay thresholds shall be Configurable by the Transportation Controller through the ATS GUI.

16. The ATS predictions of Train arrival times shall adapt to known or forecasted delays such as timed platform holds, traffic signal delay, speed restrictions.

17. Changes to predicted arrival times shall result in corrective actions by the ATS subsystem to attempt recovery of schedule and headway.

18. The train regulation function shall perform:

    a. Schedule Regulation,

    b. Headway Regulation,

19. In ATO territory, the train regulation function described in this section shall work as an Automatic Train Regulation (ATR) function, and automatically adjust Train movement to optimize schedule adherence and/or headway adherence.

20. The System shall include a command for Transportation Controllers to assign the train regulation mode (e.g., schedule regulation or headway regulation) to an entire Service Line. The selected train regulation mode shall apply to all Trains with that Service Line Assignment until another command changes the train regulation mode.

21. SFMTA may operate some Lines in Schedule regulation and some in Headway regulation at the same time. Headway regulation and Schedule regulation shall operate in the CBTC System cooperatively without requiring manual inputs to prevent undesirable end results such as lockups and undesirable conflicts between different Train routing at convergent guideway locations.

22. In the absence of impacts of Incidents that affect schedule or headway adherence (e.g., failure of switch machine or Train, or street level traffic accident), the ATS subsystem shall maintain the required performance described in Section 16.4 (System Performance).

23. The ATS subsystem shall calculate the adherence of each communicating Train in the System in real-time and provide an adherence report to SFMTA through the analytics tools.

24. The computed variation from schedule for each Train in CBTC Territory that is regulated by schedule adherence shall be displayed on the ATS GUI and represented graphically indicating the following Train conditions:

    a. Ahead of schedule

    b. On schedule – 2 minutes late

    c. 2-5 minutes late

    d. 5 or more minutes late

25. The computed variation from headway for each Train in CBTC Territory that is regulated by headway adherence shall be displayed on the ATS GUI and represented graphically indicating the following Train conditions:

    a. Bunched (headway is shorter than assigned headway by more than 2 minutes)

    b. On headway (within plus or minus 2 minutes)

    c. Gapped (headway is longer than assigned headway by more than 2 minutes)

17.5.2 ATS SCHEDULE MANAGEMENT FUNCTION

1. The ATS subsystem shall have a schedule management system where Metro service and operations are managed according to a daily timetable that determines the ATS automatic Trip assignment function, automatic route setting, and train regulation functions.

2. The ATS automatic Trip assignment function shall automatically assign Trips according to the loaded schedule to ensure each Train in CBTC Territory can depart from its origination point within the specified deviation tolerance before manual action (e.g., adjust Trip departure time, reassign/swap Trip, cancel Trip) is required by the Transportation Controllers.

3. The train regulation function shall regulate Train schedule performance by maintaining schedule/headway adherence at each scheduled arrival and departure timepoint.

4. The ATS subsystem shall import, accept and process timetable databases produced by Trapeze and the CAD/AVL system. Interface requirements to these Third-Party Systems are specified in Section 28 (Interface Requirements Specifications).

5. The ATS subsystem shall store imported timetables from Third-Party Systems in its timetable database.

6. The ATS subsystem shall have a timetable storage and database function that supports the storage of a minimum of one calendar year's worth of schedules, comprised, and categorized as weekday, Saturday, Sunday, Holiday, and special event schedules that can be populated (programmed) into an electronic calendar (load-schedule-by-calendar-date function) up to one year in advance.

7. The ATS subsystem shall use predetermined scheduling rules and apply automatic error checks without a user-confirmation when populating schedules into the electronic calendar.

    a. An example of an error-check without user confirmation would be to prevent a weekday schedule from being populated onto a Saturday or Sunday.

    b. An example of an error-check that requires a user confirmation would be when a Saturday/Sunday schedule is attempted to be populated onto a weekday.

8. The System shall have a GUI to import, manage and program schedules into the electronic calendar.

9. The ATS subsystem timetable storage and database function shall assemble and populate the daily train reporting sheet function when a timetable is loaded in the ATS System.

10. The ATS subsystem shall automatically load the daily timetable with the electronic calendar function.

11. The ATS subsystem shall allow Transportation Controllers to manually load a daily timetable by selecting a specific timetable database file. This feature will override the automatically loaded timetable for that day.

12. When the timetable is automatically loaded by the calendar function, the full-day's Train Trip schedule shall be loaded from a Configurable start time set by the Transportation Controller.

13. The ATS subsystem shall have schedule editing tools to modify the timetable database prior and during run time to account for potential changes or during operations (i.e., changing timepoints, re-baselining the schedule, service impacts/cancellations, special events).

    a. The ATS subsystem shall have functional interfaces to synchronize schedule changes made in ATS to the CAD/AVL system as described in Section 28 (Interface Requirements Specifications).

    b. The ATS subsystem shall modify the timetable database during run time to process same-day schedule changes received from the CAD/AVL system in order to remain synchronized between the CAD/AVL system and ATS.

    c. Contractor shall confer with SFMTA during the Design Phase and confirm the specific schedule editing tools needed to meet Contract requirements and SFMTA's operational needs as described in the Concept of Operations and Maintenance.

14. The ATS timetable storage and database function shall use the loaded/active ATS timetable to automatically:

    a. Generate, populate, and display the daily Train schedules for all lines/services

    b. Provide the schedule data to drive the automatic ATS Trip assignment function where Trips get automatically assigned to Trains that are located at the specified/defined Train origination/entry points in the ATS monitored territory

    c. Provide the routing assignment based on the Train's Trip assignment

15. The schedule editing tools shall create new schedules by modifying existing schedules.

16. The schedule editing tools shall determine, modify, and save service routes, which establish routing through the System, to be applied and incorporated into new and existing schedules/services.

17. The ATS timetable storage and database function shall have a repository for schedules and route definitions.

18. The ATS subsystem shall allow manual assignment or re-assignment of Trips to any station platform or stop in CBTC Territory.

19. The ATS subsystem shall include a function by which Transportation Controllers can edit and delete existing Trips and create or add unscheduled Blocks and Trips in real-time during Revenue Service.

20. The ATS subsystem shall track, record, and report for display all Trips in the daily schedule, all Trips that are assigned to a Train, all Trips that are in progress, all trips that are completed, and all modifications performed on a Trip.

21. The ATS subsystem shall include a function by which Transportation Controllers can trace a Trip back to its original Trip assignment and routing assignments.

22. The ATS subsystem shall include a function by which Transportation Controllers can manually create a replacement schedule (e.g., with new routing and service).

    a. This newly created schedule shall supplement or replace parts of an active daily schedule.

    b. The ATS subsystem shall have functional interfaces to synchronize replacement schedules made in ATS to the CAD/AVL system.

23. The ATS subsystem shall include a function by which Trips can be selected and copied as a template for new or replacement schedule.

24. The ATS System shall provide the functionality for a new or replacement unscheduled service to be created by a user by defining a Service Line, two Service Patterns forming a loop, a headway, and the service start and end time. Trains may then be assigned to this service and will continue in the loop until the service end.

25. The train regulation feature shall manage these unscheduled services in Headway regulation mode. Transportation Controllers may provide longer layovers by assigning long Dwell Times to specific platforms or stops in the Service Pattern as described in Section 17.6.4.

26. The ATS subsystem shall support flexible Trip reassignment by:

    a. Swapping assignment between pairs of Trains stopped at a station area,

b. Removing existing Trip assignment from a Train and re-assigning from a list of available Trips in the timetable,

c. Removing assigned Trip from a Train or idling Train,

d. Assigning new Trip from timetable to an idled Train,

e. Swapping Trip and idle status between idled and assigned Train stopped at a station area.

27. Manual Trip commands shall have a pre-selection function to make Trip modification selection ahead of time as follows:

a. The pre-selection function shall support selection of the Trip/s to be assigned, Train/s to be assigned to, and the location where the pre-selection will apply.

b. Once pre-selected, the command is applied by the System when applicable Train/s stops at the pre-selected assignment location.

c. The pre-selection function shall allow a Transportation Controller to select a current assigned Trip for pre-emptive termination at a specific platform in the route of the Trip and to replace the terminated Trip with the pre-selected Trip.

d. The pre-selection function shall override the automatic Trip assignment from the timetable for Trains scheduled to enter CBTC Territory at a future time.

28. The ATS subsystem shall have functional interfaces to synchronize Trip reassignments made in ATS to the CAD/AVL system.

29. The ATS subsystem shall check and verify that any manual Trip command or pre-selection command is valid and feasible for selected location, Train/s, and Trip/s at the time it is entered.

30. If a manual Trip command or pre-selection command is invalid, the ATS subsystem shall display the reason the command is invalid on the ATS GUI.

17.5.3 DAILY TRAIN REPORTING SHEET FUNCTION

1. The ATS subsystem shall have a daily train reporting sheet function that meets the following requirements:

a. The ATS subsystem shall have a real-time daily train reporting sheet function that logs, stores, maintains, and displays a listing in a tabular sheet format of the daily train operations for each Service Line and Block.

b. Applicable data fields of the daily train reporting sheet shall be automatically populated and derived from the loaded daily timetable schedule.

c. Contractor shall design and develop, with SFMTA input, the appearance and layout of the daily train reporting sheet.

d. Contractor shall include the daily train reporting sheet in the ATS Design Description Document [CDRL].

e. The daily train reporting sheet function shall keep track of deviations between the daily scheduled service and the actual service delivered by each assigned Trip and service.

f. The daily train reporting sheet function shall track and log the scheduled departure, actual departure, Trip origin, Trip destination, movement status, scheduled arrival, actual arrival at every station and terminal, and average speed for every Trip assigned/unassigned.

g. The daily train reporting sheet shall have two tables side-by-side where the Trip arrivals to the station are displayed on the left side and the Trip departures from the station are displayed on the right side.

h. The daily train reporting sheet function shall track and log the Trip's Consist, Train type, Train crew information and provide for the Transportation Controller to insert comments in free-text form in a comment field associated with each Trip entry.

i. The ATS GUI shall use a selection drop down box for Transportation Controllers to choose which station/terminal's daily train reporting sheet will display.

j. Contractor shall design the daily train reporting sheet as a popup window display on the ATS GUI tracking displays.

k. The daily train reporting sheet function shall include a feature to retrieve any daily train reporting sheets from the previous 60 Days, for viewing/printing purposes only.

l. The daily train reporting sheet shall track and report modifications made to Trips (such as routing changes, stations skipped, diversions, short turns, turn-backs, cancellations, Trip deletions, flexing, Trip swap).

m. The daily train reporting sheet function shall include filters allowing the user to select which list contents are shown.

2. The ATS subsystem shall have a query function of the data logged by the daily train reporting sheet function.

3. This data archive function shall:

    a. Produce Train and service performance reports for statistical and trend analysis.

        i. As an example, SFMTA staff may query the logs for a report containing travel times between any station stop to any station stop and/or any intersection to any intersection for each Train from which statistical analysis can be performed for operations review.

    b. Sort logged data by field function on the returned query results.

    c. Display the query on the same workstation where the query was performed.

    d. Display query results in their own popup window that shall not fully block the view of the line overview/tracking displays.

    e. Have a function to resize the windowed query results by clicking and dragging the displayed window handle.

    f. Not operate on the production database. Contractor shall provide a mirror database for Train and service performance reporting.

4. Contractor shall confirm during the Design Phase the types of Train, service, operation, and performance related reports produced through the query function.

5. Contractor shall include a detailed description on the query function and the various queries that a user can perform in the ATS Design Description Document [CDRL]

17.5.4 ONLINE HELP FUNCTION

1. The ATS subsystem shall have an online help function that includes a summary description of all ATS functions.

2. The ATS online help function shall have access to the online help information by "mouse over" of the GUI object or use of a command entry.

3. The online help function shall have a search functionality to enable Transportation Controllers to rapidly locate required user guide information.

4. The ATS online help function shall include a print function where articles may be printed.

17.5.5 FAULT REPORTING AND DIAGNOSTIC ALARMS

1. The ATS subsystem shall monitor faults, report, and manage alarms as specified herein and in Section 20.

2. The ATS archiving function shall record and save all faults and alarms in the CBTC System and alarms reported by external interfaces.

3. Records from the archiving function shall be retained in accordance with SFMTA's Records Retention Policy. A copy of this Policy is included in the Contract Documents as part of Appendix J.

4. The ATS subsystem shall have Configurable alarming of CBTC System faults and faults reported from external interfaces.

    a. A Configurable list of alarm and attributes shall be displayed in the ATS alarm Configuration file

    b. ATS alarm Configuration file modifications shall be made via text, or open format, on the alarm attributes, for example:

        i. alarm optics (visual, audio, silent/background only)

        ii. duration and reaction of alarms (for example: does alarm latch until manually cleared, how long will the alarm be displayed or sounded for)

        iii. alarm category (by criticality and severity)

        iv. alarm type (e.g., System, operational, maintenance) via text or open format Configuration files

5. The ATS subsystem shall display alarms through an always visible alarm banner on the Transportation Controller workstations.

6. The alarm banner shall display all operation critical alarms in order of severity.

7. The ATS Human Factors Analysis and Review Document [CDRL] shall include an analysis of the alarm banner design and the fault reporting and alarm function.

8. The ATS subsystem shall have an events viewer function that filters viewing and searching of alarm events.

9. Audio alarms shall have a fixed volume that is Configurable by SFMTA user role (including mute).

10. Individual users shall not be able to configure their own audio alarm volume.

11. The ATS GUI shall have a non-urgent alarm dialog window that displays all alarms and provide functionality to filter and search for alarms from the past 24 hours.

12. The ATS subsystem shall have an acknowledgement function for the Transportation Controller to acknowledge alarms.

13. The ATS subsystem shall maintain and display the acknowledgement state of each alarm.

14. The ATS subsystem shall have operational alarms for, at minimum, each of the following events when automatically detected:

    a. Conditions that cause an automatic Emergency Brake application or full-service brake application.

    b. Signal at danger violation

    c. Train Operator requesting to bypass a station.

    d. Train bypassing a station not scheduled or commanded to bypass

    e. Automatic Work Zone setup and resizing

    f. Manual Route Reservation by Train Operator

    g. Track intrusion detected by Intrusion Detection System

    h. CBTC On Board headway deviation thresholds, minimum/maximum Dwell Time violations

    i. System failures

    j. CBTC wayside Equipment failures

    k. Interlocking system failures

15. Contractor shall submit the ATS Alarm List and Priorities [CDRL] as part of the Preliminary Design Review package for SFMTA approval

17.5.6 ATS DATA ARCHIVING FUNCTION

1. The ATS subsystem shall have data logging, storage, and retrieval functions.

2. The ATS subsystem shall log all monitored, controlled, and reportable System events that shall include, but not be limited to, the following:

    a. CBTC System operations

    b. System faults and failures

    c. Emergency or full-service brake applications and causation

    d. Issuance of LMAs or track block segment reservation or equivalent data

    e. Distance of LMA or track block segment reservation length or equivalent data

    f. Alarms, alarm acknowledgements

g. Applied commands

h. Train tracking data

i. Scheduling and schedule performance data

j. Routing data

k. Operations data

l. Train performance data

m. Maintenance data.

3. The Contractor shall submit an ATS Alarm List and Priorities [CDRL] document for SFMTA review and approval as part of the System Design Documents, which describes all logged monitored, controlled, and reportable System events and the level and priority of alarm (if any), each event generates.

4. The ATS subsystem shall log all changes of the states of the System events listed in paragraph (2) in this Section 17.5.6.

5. The ATS subsystem shall provide data retrieval functions for post-failure analysis, trend analysis, performance analysis, failure analysis and investigation, and Playback functions.

6. The ATS subsystem shall timestamp all logged data and protect the data through the use of checksum and parity checks.

7. The ATS subsystem shall have a functional interface with the SFMTA Information Technology Data warehouse for data storage and retrieval, as specified in Section 28.

17.5.6.1 COMMAND LOGGING

1. The ATS subsystem shall log and timestamp all commands issued and executed by the ATS subsystem and the Local Control Panels.

2. The ATS subsystem shall retrieve and display a tabulated history of the ATS commands executed from each ATS workstation, based on login ID, in the last 2 year.

3. For every command executed from a Local Control Panel, the ATS subsystem shall log:

   a. Name/identity of the Local Control Panel Operator,

   b. Date/time,

   c. Location of platform

   d. Reason for Local Control Panel control utilization

4. The ATS subsystem shall prompt the user for any information needed to complete the log.

5. The ATS subsystem shall display on the ATS GUI, save to file, and print any returned query results.

6. The ATS subsystem shall transfer all of its archived data, including train tracking data and information related to CBTC operations, to SFMTA Data Warehouse (see Section 28.4.1) for historical review by SFMTA staff.

17.5.7 ATS PLAYBACK FUNCTION

1. The ATS subsystem shall have a Playback Function that enables Authorized users to selectively retrieve historical data from the ATS subsystem to replay the exact System conditions as if live and in sequence for use by ATS subsystem displays and on ATS Workstations.

2. The ATS subsystem shall retain all data necessary to support the Playback Function for at least two years.

3. The ATS subsystem shall include a feature that enables users to select "clips" of data, defined by two timestamps, for retention indefinitely.

4. The ATS subsystem shall support Playback of the user-selected clips until at least the end of the Contract Term.

5. The ATS subsystem Playback function shall meet the requirements specified in Section 21.2.4 (ATS Playback System).

17.6 ATS SPECIAL COMMANDS

17.6.1 ATS MANUAL OVERRIDE FUNCTION

1. The ATS subsystem shall have a manual override to prevent a train in ATO mode from departing or entering a station.

2. Contractor shall include the manual override control function as part the ATS GUI design in the GUI Displays Description [CDRL].

17.6.2 TRAIN HOLD AND RELEASE

1. The ATS GUI shall have a train hold/release command that selects an individual Train, a group of Trains, or to all Trains.

2. The ATS shall have a platform hold function that works as described in Section 17.3.4 (Incident Mitigation Functions).

17.6.3 COUPLING AND UNCOUPLING OF TRAINS

1. The ATS GUI shall include commands for coupling and uncoupling of Trains that provide the following functions:

    a. Initiating Train coupling and uncoupling operations in CBTC Territory, as specified in Section 16.3.1.3 (Coupling and Uncoupling).

    b. Manual assignment of Consist IDs which overrides the Consist IDs automatically assigned by the CBTC System when coupling and uncoupling.

    c. To initiate a Train rescue operation with a specific command, different than the Train coupling command.

17.6.4 ATS STATION BYPASS AND MANUAL CONTROL OF STATION DWELL

1. The ATS GUI shall include a station bypass (skip station) command to a Train that provides the following functions:

a. The ability to select a single platform or multiple platforms for bypass. Trains operating in ATO shall bypass the selected platform/s without stopping.

b. The ability to apply the bypass to specifically identified Train(s) for a single or multiple platforms. When applied to selected Train(s), the station bypass feature shall cause the selected Train(s) to bypass the selected platform/s the Train(s) are scheduled to serve.

c. A cancel bypass command to remove the bypass on single or multiple platforms.

d. A message to Third-Party Systems through the API as described in Section 28 (Interface Management Specifications) including the platforms(s) for which a station bypass is activated.

2. The ATS GUI shall visually distinguish the Trains and platforms for which station bypass is active.

3. The ATS subsystem shall have a global Dwell Time parameter that is set and removed by an ATS GUI command.

4. When the Dwell Time parameter is set, the System shall not give a depart command until a Train Berthed at a stop or platform has served at least the number of seconds of Dwell Time specified by the parameter.

5. The ATS subsystem shall include a manual Dwell Time feature that provides the following functions:

a. A command to input a specific Dwell Time and assign it to any individual platform, station or stop (including non-public terminal positions, pocket or tail tracks used for layover). This assigned Dwell Time shall override the global Dwell Time parameter while in effective.

b. A command to remove assigned Dwell Times from any stop, station, platform, or layover point.

c. A command allowing the user to modify previously assigned Dwell Times at a specific stop, station, platform, or layover point.

d. The Dwell Time assignment command shall enable the user to specify the time period the Dwell Time assignments are effective.

e. Users shall also be able to specify the Dwell Time assignment is in effect indefinitely.

f. The Dwell Time assignment and modification commands shall enable the user to specify which Trains the assigned Dwell Times apply to.

g. The Dwell Time assignment and modification commands shall include the following options to select which Trains the commands apply to:

i. Specify individual Trains identified by Consist ID.

ii. Specify the next “n” Trains arriving at the stop, station, platform, or layover point, where “n” is a number of Trains.

iii. Specify all Trains arriving at the stop, station, platform, or layover point.

h. A message to Third-Party Systems through the API as described in Section 28 (Interface Management Specifications) communicating the set Dwell Times for each stop, station, platform, or layover point. When Trains are Dwelling at a stop, station, platform, or layover

point, the ATS subsystem shall include the remaining Dwell Time in Vehicle status messages sent through the API.

6. Once a Train has Berthed at a stop, station, platform, or layover point and is Dwelling, the remaining Dwell Time shall not be restarted for any reason. However, the assigned Dwell Time for that Train may be modified using the command described in paragraph (3)(c) to shorten or extend the Dwell.

7. The System shall deactivate the door close pushbutton until after the Dwell Time has expired to prevent early departures.

17.7 ATS INTERFACES

17.7.1 EMERGENCY STOP BUTTONS

1. The ATS GUI shall indicate the activation of the Market Street Emergency Stop Button, the Central Subway Emergency Stop Button and the MMT Emergency Stop Button on the Transportation Controllers' ATS workstations.

2. The ATS GUI indications shall distinguish the region of CBTC Territory that is affected by the emergency stop button activation.

3. The ATS GUI shall display different symbology when the Market Street Emergency Stop Button, the Central Subway Emergency Stop Button and the MMT Emergency Stop Button are activated, to distinguish which button has been activated.

4. The ATS GUI shall clearly indicate the Trains that were ordered an emergency stop via an Emergency Stop Button command on the Tracking Displays.

5. The ATS GUI indication shall visually distinguish Trains that were ordered an emergency stop via an Emergency Stop Button command from other Trains.

17.7.2 BLUE LIGHT SYSTEM

1. The ATS subsystem shall receive activation alarms from the Blue Light System.

2. The ATS subsystem shall indicate to Transportation Controllers that a Blue Light System has been activated.

3. The ATS subsystem shall indicate on the ATS tracking displays the location and time of a Blue Light System activation.

4. ATS indications of a Blue Light System activation shall remain on until the Blue Light System is deactivated.

17.7.3 INTERLOCKING LOCAL CONTROL PANEL

1. The Local Control Panels shall be able to control Interlockings even while there is complete loss of communications between the Interlocking and the ATS or the CBTC System, as described in Section 16.3.1.4 (Interlocking Local Control Panel)

2. The ATS subsystem shall prevent the ATS GUI from issuing commands to an Interlocking/Junction point that is being controlled from its Local Control Panel.

3. The ATS subsystem shall relinquish control of the Interlocking to the Local Control Panel when the Local Control Panel is activated by authorized SFMTA personnel.

4. The ATS subsystem shall relinquish control of the Interlocking to the Local Control Panel without Transportation Controller intervention.

5. The Local Control Panel shall have a functional interface to allow the Local Control Panel operator to return control to the ATS System.

6. The ATS subsystem shall require confirmation from the Transportation Controller before transferring control from the Local Control Panel back to the ATS System.

7. The ATS subsystem shall have and enforce a control hierarchy scheme such that an authorized user at a Control Center ATS workstation may recover control of an Interlocking from an active Local Control Panel by issuing a command.

    a. This command shall not be available while a Vehicle is in the Interlocking.

    b. The Local Control Panel shall relinquish control without action from the Local Control Panel operator.

8. Contractor shall submit the design of the layout of the controls and indications to be displayed on the Local Control Panels and ATS GUI as part of the ATS subsystem design as described in ATS Design Description Document [CDRL], ATS Human Factors Analysis and Review Document [CDRL], and GUI Displays Description [CDRL].

9. The ATS line overview, train tracking displays and Local Control Panels shall indicate the status of the Interlocking/Junction point control mode (e.g., Local or ATS) using GUI symbols or lights.

10. The ATS line overview and train tracking displays shall visually distinguish (such as using shading) the area controlled by an active Local Control Panel from the rest of the area supervised by the ATS.

11. The ATS subsystem shall continue to provide Interlocking control status indications to Transportation Controllers using the ATS GUI when the Interlocking is in Local Control Panel control mode and has an active network connection to the ATS.

12. The ATS GUI shall graphically indicate a loss of communication with Interlockings by visually distinguishing the region of control that has lost supervision.

13. Certain ATS System commands shall still apply even while an Interlocking is being controlled by a Local Control Panel.

14. Contractor shall list the ATS System commands that still apply even while an Interlocking is being controlled by a Local Control Panel in the ATS Design Description Document.

17.7.4 TRAIN DEPART LOCAL CONTROL CONSOLE

1. Contractor shall Furnish Train Depart Local Control Consoles at all platforms identified in Section 16.3.1.5 (Train Depart Local Control Console).

2. The Train Depart Local Control Consoles shall issue a train depart command to a Train Berthed at the platform that the Train Depart Local Control Console controls, when the Train Depart Local Control Console is activated and the button is pressed.

3. The ATS GUI shall have a command to activate Train Depart Local Control Consoles for use.

    a. The activation command shall allow users to select one or multiple Train Depart Local Control Consoles.

    b. The activation command shall require the user to input the duration that the Train Depart Local Control Consoles will be active.

    c. The Train Depart Local Control Consoles shall deactivate automatically after the set duration expires.

4. The ATS GUI shall have a command to immediately deactivate one or multiple Train Depart Local Control Consoles.

5. The ATS subsystem shall indicate on the line overview and train tracking displays each Train Depart Local Control Console's activation status, including the activation start and end time.

17.7.5 CUSTOMER INFORMATION SYSTEMS

1. The ATS subsystem shall interface with the onboard passenger information system via API as specified in Section 28 (Interface Requirements Specifications) to activate pre-written and pre-recorded visual and audio message announcements such as next station, destination, and public safety announcements.

2. To enable passenger information display systems to operate on station platforms, the ATS subsystem shall provide the predicted Train arrival time, along with Train Service Line Assignment and other identifying information for every station/timepoint in CBTC Territory to Third-Party Systems.

3. The requirements for the interface between the ATS subsystem and Third-Party Systems are specified in Section 28 (Interface Requirements Specifications).

17.7.6 CAD/AVL SYSTEM

1. The ATS subsystem shall interface with the CAD/AVL system via API as specified in Section 28 (Interface Requirements Specifications).

2. The ATS subsystem shall provide Vehicle status messages to the CAD/AVL system via API as specified in Section 28 (Interface Requirements Specifications).

3. The ATS subsystem shall send and receive schedule information to and from the CAD/AVL system as provided for in Section 17.5.2 (ATS Schedule Management Function).

17.7.7 STREET TRAFFIC SIGNAL CONTROLLER

1. The ATS subsystem shall interface with the street Traffic Signal Controllers on surface sections, as specified in Section 28.8 (Traffic Signal Controller), to minimize signal delays to Trains at street intersections.

2. The ATS subsystem shall provide predicted arrival times of next 3 Trains in each direction to each Traffic Signal Controller. The Traffic Signal Controller will use the prediction data for traffic signal prioritization and to improve the on-time performance of Trains.

3. The Traffic Signal Controller will send the traffic signal cycle, the current signal phase, and the time to next phase to the ATS. The ATS subsystem shall receive and process this information from the Traffic Signal Controller and use this information in the ATS train regulation function.

4. The ATS train regulation function shall take into account the information obtained from the Traffic Signal Controller when calculating the recommended speed to display on the TOD in Street Mode.

5. The ATS shall send the traffic signal phase to the TOD.

17.7.8 TRACTION POWER AND VENTILATION SYSTEMS

1. The ATS subsystem shall divide CBTC Territory into Traction Power Sections and Tunnel Ventilation Sections, based on the layout of the traction power system and tunnel ventilation systems.

2. The ATS subsystem shall display the maximum number of LRVs allowed in each section.

    a. The calculation for the maximum number of LRVs that may be present in a Traction Power Section shall take into account all adverse traction power operating and failure conditions, including the maximum traction power needed and available to each traction power section so Trains moving from standstill simultaneously shall not overload or trip the circuit breakers for that Traction Power Section.

    b. The calculation of the maximum number of LRVs that may be present in any Tunnel Ventilation Section shall be based on the risk impact analysis of the ventilation system operation, CPUC regulations, and Fire Code and other applicable safety regulations.

3. The ATS subsystem shall prevent LRV capacity limits from being exceeded in Traction Power Sections and Tunnel Ventilation Sections by limiting the number of Trains allowed to enter and operate within the sections.

4. The ATS subsystem shall take Consist length into account when performing this function.

5. The ATS subsystem shall automatically regulate starts and station holds to enforce the maximum number of Train starts within a Traction Power Section.

6. The ATR function shall regulate the schedule and/or headway of Trains within the Traction Power Section and Tunnel Ventilation Section limitations.

7. The ATS subsystem shall have manual override functions for Transportation Controllers to:

    a. Selectively add additional Trains that would exceed the limits in the track section,

    b. Set the maximum number of LRVs that can enter and operate in the track section, and

    c. Set the limits of each track section.

8. The ATS subsystem shall activate an alarm when the number of LRVs within a Traction Power Section or Tunnel Ventilation Section is approaching the limit of LRV capacity for that section.

17.8 AUTOMATIC TRAIN SUPERVISION (ATS) FUNCTIONS CDRLS

Table 17-20: ATS CDRL Table

CDRL #	CDRL Title
17.01	ATS Design Description Document
17.02	ATS Software Architecture
17.03	ATS Human Factors Analysis and Review Document
17.04	ATS Alarm List and Priorities
17.05	GUI Displays Description
17.06	ATS Screen Displays for the Video Wall
17.07	Detail and information to be included in the line overview and train tracking displays
17.08	ATS Mobile Application Design Description

18 AUTOMATIC TRAIN OPERATION (ATO) FUNCTIONS

18.1 PURPOSE

1. This Section 18 contains the requirements for the Automatic Train Operation functions of the CBTC System.

18.2 GENERAL ATO SPECIFICATIONS

1. The CBTC System shall perform the Automatic Train Operation (ATO) functions described in this Section.

2. The Automatic Train Protection (ATP) functions shall continually monitor operations in ATO for safety.

3. Contractor shall design and supply a CBTC System which provides UTO and ATO at GoA4 to be used on Trains in ATO Territory, as defined in Section 22.3 (Normal Operating Modes and Territories).

4. Contractor shall test, commission, and demonstrate full UTO at GoA4 in the entire ATO Territory prior to Final Acceptance. The Contractor shall submit a document to SFMTA at the time the UTO functionality is Commissioned stating the conditions that must be met in order to operate a Train in UTO outside of UTO Territory.

5. The CBTC System shall prevent a Train in ATO mode from entering Street Territory or operating in ATO mode outside of ATO Territory.

6. Heritage and Maintenance Vehicles shall not be capable of ATO or UTO.

7. Contractor shall configure the System to limit automation as specified in Section 22 (Modes of Operation).

8. In ATO mode:

    a. The VOBC shall automatically control Train acceleration, deceleration, Train speed, station stops and door opening within ATP supervision limits.

    b. The ATS subsystem shall route Trains in ATO Territory as described in Section 17.5, either automatically or manually based on Transportation Controller commands.

    c. The Train shall travel from one station to the next and properly Berth itself at each station platform as further described in Section 18.4.

    d. The VOBC shall confirm all doors are closed as a condition of departing any Berthing locations.

    e. The VOBC shall require the Train Operator to push an automatic train departure button (ATO Start Button) before starting Train movement in ATO mode once Train has stopped at any Berthing locations.

9. The Berthing locations where the ATO Start Button press is required by the Train Operator shall be specified in the Design Documents and the CBTC database.

10. The amount of time the Train doors remain open (Dwell Time) at a station shall be partially controlled by the ATO functionality. The Train Operator closes the doors using a door close pushbutton inside the operator cab. The Train is eligible for departure after the Dwell Time has expired.

    a. The VOBC shall inform the Train Operator, using visual and audible indicators at the expiration of Dwell Time to execute the door close command and depart the station.

    b. The VOBC shall deactivate the door close pushbutton until after the Dwell Time has expired to prevent early departures.

11. The ATO functions of the CBTC System shall support energy optimization for Trains operating in ATO mode through the real-time control and coordination of Train acceleration, Train coasting, and Train braking.

12. Energy optimization operations shall not induce oscillation in Train velocity or cause the Vehicle to jerk, or otherwise impact passenger ride quality.

13. Contractor shall submit a ATO System Design document [CDRL] containing the detailed description of all ATO, functions, Hardware, and interfaces, for SFMTA approval as part of the Preliminary Design Review submittal.

14. Contractor shall submit the ATO Software Architecture [CDRL] containing the detailed description of the ATO Software, as part of the System Design Documents.

18.3 AUTOMATIC SPEED REGULATION

1. The Automatic Speed Regulation (ASR) function shall automatically regulate the speed of Trains operating under ATO mode.

2. The ASR shall automatically and continuously control the starting, stopping, and speed regulation of a Train as it travels between stations so that the cruise speed, acceleration, deceleration, and jerk rates are within specified passenger comfort limits specified in the Standards identified in Section 7, and that the Train speed is maintained below the overspeed limits imposed by the ATP function.

3. ASR algorithms shall support multiple cruise speeds, acceleration, and braking rates (i.e. performance levels) to support the various traction conditions that LRV4s experience in Revenue Service.

4. The ASR function shall perform speed control and accept velocity, braking and acceleration rate changes as specified in the System Design Documents without initiating emergency braking.

5. ASR control of velocity shall have an accuracy of ± 1 mph to the ATO operation profile through all Phases of Train travel from wheel start to wheel stop.

6. The ATP overspeed protection profile shall accommodate ASR speed variation specified in this Section.

18.4 PLATFORM BERTHING CONTROL

1. The CBTC System shall perform automatic Berthing control when in ATO Mode.

2. The Contractor shall identify specific Berthing locations in the System Design Documents based on SFMTA operational requirements reviewed during the Design Phase, including at least the following: platforms or stops, including non-public stops, pockets or tail tracks used for layover.

3. The VOBC shall automatically control the Train's movement Berthing at these Berthing locations.

4. Platform Berthing features shall support required System Performance levels as described in Section 16.4 (System Performance).

5. The automatic Berthing control function shall support 1, 2, 3, and 4 car Consists.

6. For each station/platform area the System shall support definition of multiple pre-determined Berthing locations.

7. The ATS interface shall include functionality to allow the Transportation Controller to select a specific Berthing location for each platform.

8. The selected Berthing location shall remain in effect until changed by a subsequent user command and be retained after any restart of the ATS server such that it does not have to be re-entered after a restart.

9. Some SFMTA stops/platforms are shorter than the maximum Consist length. For Consists longer than Contractor-designed limit established for the platform, the CBTC System shall disable specific doors from opening, as Configured by SFMTA.

10. In ATO mode, when a preceding Train has movement authority and has begun accelerating to depart the station, the CBTC System shall give movement authority for the next Train to Berth at the platform.

11. In ATO mode, the CBTC shall not give movement authority for a Train to partially leave a station. The movement authority for a Train departing a platform shall have sufficient distance for the Train to completely clear the station platform and allow the following Train to Berth.

12. The Train's VOBC shall safely control Berthing to within an accuracy of ± 1 feet of the stop position(s) defined in the System Design Documents for each platform.

13. If a Train unexpectedly stops before the defined Berthing location for a platform (undershoot), the CBTC System shall automatically move the Train to its proper Berthing location when the Train Operator confirms that the automatic recovery operation is safe.

14. If a Train unexpectedly stops beyond the defined Berthing location (overshoot) exceeding Berthing accuracy tolerance and some doors are beyond the safety limit of the platform, the System shall disable those doors from opening.

15. If the entire Train stops beyond the safety limit of the platform, the CBTC System shall require the Train Operator to press the ATO Start Button to continue to the next station provided movement authority is granted by the CBTC System.

16. The CBTC System shall complete calculations required to determine Berthing is within required stopping accuracy requirements not more than 0.5 seconds after the Train has stopped.

17. The CBTC System shall perform automatic Berthing functions at specific locations that are not public stops or platforms, such as turnback pocket tracks or intermediate stopping locations.

18. The CBTC System shall prevent the automatic door control function from automatically opening the doors at these locations.

19. The CBTC System shall log each instance where the Train Berthing exceeded the accuracy tolerance defined in this Section.

20. The CBTC System shall send an alarm to the ATS GUI if one or more doors are beyond the safety limit of the platform due to an overshoot.

21. Contractor shall submit a Berthing Safety Analysis [CDRL] at the Final Design Review for SFMTA approval.

18.5 AUTOMATIC DOOR CONTROL

1. The CBTC System shall automatically command Trains to open Train doors at predetermined locations in ATO Territory. The expected features and behavior of the ATO functions for automatic door control are listed in this Section.

2. The CBTC System shall determine if the Train doors can open safely before enabling Train doors.

    a. The System shall complete the evaluation in 0.5 seconds after Train has come to a stop.

    b. Total time from wheel stop to automatic door opening shall not exceed 0.6 seconds.

3. In ATO Mode The CBTC System shall stop Trains at defined Berthing locations and command Trains to automatically open doors.

4. The CBTC System shall issue an alarm to the Train Operator and the Transportation Controller if doors fail to open automatically when automatic opening of doors should have occurred.

5. The CBTC System shall disable automatic opening of specific Train doors beyond the safety limit of the platform as Configured by SFMTA.

6. The CBTC System shall prevent the automatic door control function from automatically opening the doors when the Train Operator depresses the door close button before doors are automatically opened.

7. The CBTC System shall allow the Train Operator to reopen the doors until the engagement of the ATO Start Button.

8. Door closing in ATO Mode shall be initiated by activation of the door close button.

9. The CBTC System shall supervise the door closing when Train is under ATO operation and prevent closing of Train doors if safety conditions do not allow closing of doors.

10. The CBTC System shall issue an alarm to the Train Operator and Transportation Controller if the doors fail to close after the Train Operator presses the door close button.

11. If Train doors are manually disabled or door sets are cut-out, the CBTC System shall perform automatic door open operation for all other door sets that are not manually disabled or cut-out.

12. The manual disabling or cut-out of any door set shall not impact automatic door open for all other Train doors that are not disabled or cut-out.

18.6 STATION BYPASS

1. The CBTC System shall have a station bypass function. The expected features and behavior of the ATO functions for station bypass are listed in this Section and in Section 17.6.4.

2. The ATS GUI shall include commands:

    a. Activating a station bypass for all Trains, for the station(s) designated in the command.

    b. Activating the station bypass for specific Trains for the station(s) designated in the command. The GUI shall prompt the user to enter or select the specific Trains.

    c. Deactivating the station bypass for the station(s) designated in the command.

3. When a station bypass is active, all Trains, or the individual Train(s) designated in the station bypass command, shall bypass the station(s) selected for bypass.

4. While a station bypass command is active, the TOD shall display a station bypass indication when approaching the bypassed station.

5. The System shall enable the Train Operator to initiate a station bypass using a command in the TOD or a physical control in the operator cab during emergencies.

    a. The Train Operator-initiated station bypass shall only apply to the Train from which it was initiated.

    b. The Train Operator-initiated station bypass shall only apply to the next station and to the current Trip.

6. The CBTC System shall provide information to the onboard systems enabling the Vehicle PA system to make automatic announcements to passengers regarding the station bypass.

7. The Train Operator or Transportation Controller shall be able to disable the station bypass announcement.

8. The CBTC shall suppress station stop overrun notices to the TOD and the Transportation Controller when the station has been designated to be bypassed.

9. Trains shall not exceed 10 MPH when traveling through a bypassed station.

18.7 AUTOMATIC TURNBACK

1. The CBTC System shall operate Trains in UTO mode in the MMT (Muni Metro Turnback) facility between Embarcadero Station and one of the MMT pocket tracks when the Automatic Turnback feature is activated, as described in Section 18.7.1 (Automatic Turnback at MMT).

2. The CBTC System shall operate Trains in UTO mode between each Chinatown platform and a not-in-service Berth in each Central Subway tail track north of Chinatown station when the Automatic Turnback feature is activated, as described in Section 18.7.2 (Automatic Turnback at Central Subway Tail Tracks).

3. If a command to disable Automatic Turnback is received or the UTO Emergency Stop Button is pressed while Trains are operating in UTO mode:

a. The CBTC System shall stop all Trains in UTO Mode using full-service brakes.

b. Trains stopped in this way shall not resume operations in UTO mode if Automatic Turnback is subsequently re-enabled.

c. Trains stopped in this way shall be recovered by a Train Operator as described in Section 22.6.1.

4. The Automatic Turnback procedure shall be available for use when the "UTO Available" indication is displayed. The Train Operator will initiate the Automatic Turnback procedures after disembarking all the passengers.

5. The CBTC System shall interface with SFMTA's platform intrusion detection system as described in Section 19.13 (Intrusion Detection).

6. The CBTC System shall ensure safe conditions for Unattended Train Operation described in the Automatic Turnback Safety Analysis are met before allowing the Train to leave the platform in UTO Mode.

7. Contractor shall submit an Automatic Turnback Safety Analysis [CDRL] covering operations at both the MMT and Central Subway tail tracks as part of the System Design Documents.

18.7.1 AUTOMATIC TURNBACK AT MMT

1. The CBTC System shall have an Unattended Train Operation (UTO) Automatic Turnback function between Embarcadero Station and the MMT pocket tracks as described in Section 22.3.1.1 (Muni Metro Turnback).

2. The ATS GUI shall have a command for the Transportation Controllers to enable/disable Automatic Turnback at the MMT.

3. When Trains are routed to turnback at MMT, the System shall dynamically assign them to any available pocket track which is compatible with the Consist length.

4. Immediately prior to reserving switch T7 for a Train, the System shall reevaluate the Train's pocket track assignment.

5. If the assigned pocket track is occupied, the System shall reassign the Train to an unoccupied pocket track, if one is available, sufficiently in advance so that that the Train may proceed through T7 without stopping.

6. If all pocket tracks are occupied, the System shall stop the Train at signal T4 (short of switch T7) and assign the Train to the next available pocket track.

7. The TOD shall display a "UTO Available" indication when the following conditions are met:

a. The Train is Berthed at the Embarcadero eastbound platform.

b. The Train is assigned routing to an MMT pocket track.

c. The Automatic Turnback feature is enabled.

8. The Automatic Turnback feature operation at MMT shall follow this sequence:

a. Train Operator selects UTO mode on the mode selector in the cab of the Train.

b. Train Operator confirms ‘UTO Ready’ indication on the TOD.

c. Train Operator steps out of the cab and onto the platform, and closes the single leading cab door

d. Train Operator confirms that platform conditions are safe to depart and commands the departure of the unattended Train using the Automatic Turnback Console on the platform.

e. The Train travels in UTO to a pocket track selected by the ATS, Dwells for the specified Dwell Time, switches ends automatically, and departs for Embarcadero westbound platform.

f. The Train arrives at Embarcadero westbound platform in UTO mode, Berths at the platform and opens all doors. A Platform Operator will supervise the Train movement from the westbound platform Automatic Turnback Console and stop the Train in case of emergency by means of an emergency stop button on the console.

g. A relief Train Operator boards the Train along with passengers.

h. Once aboard the Train, the Train Operator selects ATO mode using the mode selector in the cab of the Train and continues operations in ATO mode in the westbound direction.

9. The CBTC System shall include a function to set/modify the Train’s Dwell Time in the pocket as specified in Section 17.6.4 (ATS Station Bypass and Manual Control of Dwell).

18.7.2 AUTOMATIC TURNBACK AT CENTRAL SUBWAY TAIL TRACKS

1. The CBTC System shall have an Unattended Train Operation (UTO) Automatic Turnback function to move a one- or two-car Train between each Chinatown platform and its corresponding tail track as described in Section 22.3.1 (Central Subway Tail Tracks).

2. The ATS GUI shall have a command for the Transportation Controllers to enable/disable Automatic Turnback in Central Subway.

3. The TOD shall display a “UTO Available” indication when the following conditions are met:

   a. The Train is Berthed at either Chinatown platform.

   b. The Train is assigned routing to a Central Subway tail track.

   c. The Automatic Turnback feature is enabled.

4. The Automatic Turnback feature operation in Central Subway shall follow this sequence:

   a. Train Operator selects UTO mode on the mode selector in the cab of the Train.

   b. Train Operator confirms ‘UTO Ready’ indication on the TOD.

   c. Train Operator steps out of the cab and onto the platform, and closes the single leading cab door

   d. Train Operator confirms that platform conditions are safe to depart and commands the departure of the unattended Train using the Automatic Turnback Console on the platform.

   e. The Train travels in UTO to the tail track, Berths, switches end automatically and idles. The Train may be stored indefinitely in the tail track until retrieved.

f. To retrieve the Train, the Train Operator confirms that platform conditions are safe and commands the return of the unattended Train using the Automatic Turnback Console on the platform.

g. The Train arrives at the platform in UTO mode, Berths at the platform and opens all doors. The Train Operator will supervise the Train movement from the platform Automatic Turnback Console and stop the Train in case of emergency by means of an emergency stop button on the console.

h. The Train Operator boards the Train along with passengers.

i. Once aboard the Train, the Train Operator selects ATO mode using the mode selector in the cab of the Train and continues operations in ATO mode in the southbound direction.

5. When the Train is Berthed in the tail track, it is out of service and shall not be included in Dwell calculations or prediction lists.

6. When a Train is moved from the tail track to the Chinatown platform, it is in service. It shall be assigned to the Schedule Block logged into in CAD/AVL system and assigned any applicable platform Dwell Times upon arrival.

18.8 AUTOMATIC TRAIN OPERATION (ATO) FUNCTIONS CDRLS

Table 18-21: ATO CDRL Table

CDRL #	CDRL Title
18.01	ATO System Design
18.02	ATO Software Architecture
18.03	Berthing Safety Analysis
18.04	Automatic Turnback Safety Analysis

19 AUTOMATIC TRAIN PROTECTION (ATP) FUNCTIONS

19.1 PURPOSE

1. This Section specifies CBTC System Automatic Train Protection (ATP) functions, which shall comply with the requirements listed in this Section.

2. The ATP functions shall conform to the IEEE 1474.1 Standard in ATO and UTO Territory.

19.2 ATP FUNCTIONS

1. The ATP shall protect CBTC equipped Trains in CBTC Territory while Trains operate in manual driving and in automatic modes.

2. The CBTC System ATP shall have, at a minimum, the functions listed in Table 19-1. Contractor may provide additional functions as required to comply with the Standards listed in Section 7 or to address identified Hazards:

Table 19-1 ATP Functions

ATP function	CBTC Territory		
	ATO and UTO Territory	**Surface Interlockings**	**Surface (other than Interlockings)**
a. Train location and speed determination	Shall be Vital	Shall be Vital	Shall be non-vital
b. Train length determination	Shall be Vital	Shall be Vital	Shall be Vital
c. Safe Braking	Shall be Vital	Shall be non-vital	Shall be non-vital
d. Safe train separation	Shall be Vital	Shall be non-vital	Shall be non-vital
e. Continuous speed enforcement and overspeed warning	Shall be Vital	Shall be non-vital	Shall be non-vital
f. Interlocking functions	Shall be Vital	Shall be Vital	N/A
g. Train door interlock	Shall be Vital	Shall be non-vital	Shall be non-vital
h. Rollback protection	Shall be Vital	Shall be non-vital	Shall be non-vital
i. End of track protection	Shall be Vital	N/A	Shall be non-vital

j.	Parted train protection	Shall be Vital	Shall be non-vital	Shall be non-vital
k.	Intrusion Detection interface	Shall be Vital	N/A	N/A

3. Maintenance and Heritage Vehicles shall not have ATP onboard functions, such as speed enforcement and braking. However, CBTC-equipped Trains shall be kept away from these Vehicles. See Section 19.6 (Safe Train Separation) for details.

4. Obstacle detection functions, if provided, shall conform to Verband Deutscher Verkehrsunternehmen (VDV) recommendation 191 01/2019 Advanced Driver Assistance Systems for tramcars for avoidance of collisions with obstacles situated directly on the track. Alternate standards may be substituted as provided for in Section 7.1.

5. Non-vital ATP functions may still automatically apply brakes as necessary to meet requirements in these Specifications, or if there is no specific requirement, may apply brakes at Contractor's discretion. ATP functions that do not automatically apply brakes shall provide audio and visual warnings to alert the Train Operator to apply brakes.

6. The System shall use the Driver Assist and Penalty Braking functionality described in Section 19.7 (Speed Enforcement / Overspeed Warning) to non-vitally enforce authorized LMA in Street Mode, (e.g., the Train will be stopped in advance of another communicating Train or non-permissive signal).

    a. The System shall log these LMA enforcement events.

    b. The System shall allow SFMTA to disable this function as a System Configuration.

7. All CBTC braking functions shall use service brakes and not Emergency Brakes, except as specified below.

8. The VOBC shall only apply the Emergency Brakes (EB) when all of the following conditions are met:

    a. The FSB has been applied,

    b. The speed of the Train continues to increase, and

    c. The Train’s speed exceeds the ATP system-determined safe speed by the EB tolerance.

9. Contractor shall submit the ATP System Design [CDRL], containing the detailed description of ATP architecture, Hardware, functions, and interfaces as part of the Preliminary Design Review submittal.

10. Contractor shall include the ATP Software Architecture [CDRL] containing the detailed description of the ATP Software in the System Design Documents.

19.3 VEHICLE LOCATION AND SPEED DETERMINATION

1. The CBTC System shall continuously determine the location, speed, and travel direction of each CBTC equipped Vehicle operating in CBTC Territory, including LRVs, Heritage Vehicles and Maintenance Vehicles, using the Vehicle’s active Onboard Computer (VOBC).

2. The following table summarizes the conditions under which vehicle location and speed determination are vital or non-vital:

Table 19-2 Vehicle Location and Speed Determination

Vehicle / Operating Mode	CBTC Territory			
	UTO Territory	**ATO Territory**	**Street Territory (at Interlockings)**	**Street Territory (not at Interlockings)**
a. LRV / UTO	Shall be Vital	Shall be Vital	N/A	N/A
b. LRV / ATO	Shall be Vital	Shall be Vital	N/A	N/A
c. LRV / ATPM	Shall be Vital	Shall be Vital	N/A	N/A
d. LRV / Street	N/A	N/A	Shall be Vital	Shall be non-vital
e. LRV / Manual	Shall be Vital	Shall be Vital	Shall be Vital	Shall be non-vital
f. Heritage Vehicles	N/A	N/A	Shall be Vital	Shall be non-vital
g. Maintenance Vehicles	Shall be Vital	Shall be Vital	Shall be non-vital	Shall be non-vital

3. Vehicle location and speed determination shall be a vital function in all Modes of Operation in ATO Territory, UTO Territory and at Interlockings in Street Territory.

    a. Contractor shall define the location of Interlocking boundaries delineating where location and speed determination shall be vital and include these boundary definitions in the System Design Documents.

    b. For LRV vital location and speed determination, the VOBC shall determine the position of the Train using the LRV's tachometers and by detecting transponders located in the track bed.

    c. The LRV VOBC shall use the transponders to provide absolute guideway position references.

    d. If the VOBC does not have position established, the Vehicle’s position shall be non-vitally tracked using GPS, even if the VOBC has failed, provided the MCG is working normally.

4. The CBTC Vehicle location determination functions shall have a resolution at least as accurate as described in Table 19-3, based on location. Berthing locations are described in Section 18.4.

Table 19-3 Location Accuracy Requirements

Location (All CBTC Territory)	Resolution	Frequency
At Berthing locations	+/- 1 foot	98% of the time
At Berthing locations	+/- 3 feet	99.997% of the time
At other stopping locations (e.g., signals)	+/-5 feet	99.997% of the time

5. The CBTC Vehicle location resolution and accuracy shall support the performance, capacity, and safety requirements stated in these Contract Specifications.

6. The CBTC Vehicle location determination function shall perform self-initialization and automatic detection to establish the location of each CBTC-equipped Vehicle as it enters CBTC Territory, and on recovery from CBTC Equipment failures, without requiring any manual intervention.

7. The CBTC System shall compensate for the effects of measurement inaccuracies on Train location and speed determination if the CBTC Train location/speed determination function is dependent upon wheel rotation.

    a. The CBTC System shall automatically compensate for position errors induced by the slipping or sliding of wheels.

    b. The CBTC System shall automatically compensate for position errors caused by variation in wheel size due to wear, truing, or replacement.

8. The LRV VOBC shall continuously calculate a dynamic position uncertainty.

    a. The dynamic position uncertainty value will increase with the distance travelled from the last transponder and shall be reset each time a transponder is read.

    b. The Contractor shall design the placement of transponders such that this dynamic position uncertainty never exceeds a prescribed limit under normal system operations and state of good repair.

    c. The prescribed dynamic position uncertainty limit shall be stated in the System Design Documents.

9. If at any time during ATO, UTO, or ATPM operations the calculated position uncertainty exceeds the prescribed limit, the LRV VOBC shall communicate the position of the Train as unknown and shall apply a vitally supervised Full-Service Brake.

    a. Upon reaching a stop, all CBTC Operating Modes except Manual shall be unavailable until the VOBC re-establishes a valid position for the Train.

    b. The CBTC System shall handle a Train with an unknown position as a Non-Communicating Train as described in Section 22.4.3 (Loss of Communications).

c. Train position errors shall not affect the ability of the Train to communicate with the CBTC System or non-vital functions of the CBTC, such as ability of the ATS subsystem to supervise the Train.

d. The CBTC System shall assign larger safety distances around Trains with position errors that correspond to the magnitude of the position errors.

e. Trains with position errors that prevent operations in ATO mode shall trigger alarms at the AMS and ATS workstations.

10. The CBTC System shall have a zero-speed detection function in accordance with the requirements of Section 5.11 of the IEEE Standard 1475-2012. Zero speed is defined as the speed of a Train is less than 0.5 MPH.

19.3.1 VEHICLE DETECTION

1. Vehicle detection shall be a vital function in ATO Territory, UTO Territory and at Interlockings in Street Territory.

   a. Contractor shall design Equipment for use on Heritage and Maintenance Vehicles, as described in Sections 2.4.2 and 2.4.3, which meets this requirement.

   b. If SFMTA elects not to exercise the Options, Contractor shall meet this requirement by providing procedures for the SFMTA to use to separate unequipped Vehicles from equipped Vehicles, such as reserving sections of track for unequipped Vehicles to operate.

2. Contractor shall not use a secondary train detection system in ATO Territory and UTO Territory.

3. Vehicle detection shall rely on the Vehicle Location and Speed Determination described in Section 19.3.

4. Contractor shall provide SFMTA with procedures to ensure safety in the event of a communications failure or Vehicle detection failure where the position of an equipped Vehicle is unknown.

5. Contractor shall include a Train Presence Detection Design document [CDRL] as part of the Preliminary Design Review submittal, to describe the proposed solution to determine the location of all Vehicles in CBTC Territory.

19.4 TRAIN LENGTH DETERMINATION

1. The CBTC System shall support Consists of varying lengths from one car to four cars.

2. The CBTC System shall determine Consist lengths to the resolution necessary to meet Contract safety and performance requirements.

3. The System shall vitally determine the Consist length using information provided to it via the Trainline, OrbCAD or user input.

19.5 SAFE BRAKING

1. Contractor shall develop and submit a Safe Braking Model Analysis [CDRL] that conforms with the IEEE 1474.1 Standard.

2. The Safe Braking Model Analysis shall address the following factors:

a. Location uncertainty of Vehicles (including rollback tolerance) in all CBTC areas.

b. Consist length for all Trains.

c. Vehicle characteristics.

d. Allowable overspeed permitted by the CBTC System.

e. Maximum speed measurement error.

f. System reaction times and latencies.

g. Maximum Train acceleration rate possible at the time an overspeed condition is detected.

h. Worst-case operator reaction times to disable the propulsion system and apply full-service brakes following detection of an overspeed condition by the CBTC.

i. Guaranteed Emergency Brake Rate (GEBR). Contractor shall use data provided from the Vehicle Supplier to support the confirmation of the GEBR.

j. Grade of trackway.

3. ATP functions shall incorporate appropriate protection to ensure that the correct safe braking model is applied for any given Train in CBTC Territory.

4. The Contractor shall design ATP functions to use service brakes for all braking functions described in these Specifications, unless a braking function is specifically required to use Emergency Braking (EB).

5. The Contractor shall design ATP functions so that they limit the application of Emergency Braking (EB) only to the scenarios where FSB application to bring a Train to a stop would be ineffective.

6. Contractor shall submit a list of the conditions which require EB application, including rationales, as part of the CBTC System design for SFMTA approval as part of Preliminary Design Review.

7. The VOBC shall maintain EB application until the CBTC System determines that the unsafe condition(s) which triggered the use of EB are no longer present.

8. After an EB application, the VOBC shall only permit resumption of Train operations after the Train Operator has reset the EB.

19.6 SAFE TRAIN SEPARATION

1. The ATP functions of the CBTC System shall maintain, for all communicating Trains in CBTC Territory, safe separation from all other:

   a. Communicating Trains, regardless of operating mode

   b. NCTs (or last known position of NCTs called NCOs) as described in Section 22.4.3 (Loss of Communications)

   c. Guideway ends and other fixed obstructions

2. The CBTC System shall non-vitally assist the Train Operator in maintaining separation between equipped Trains, Heritage Vehicles and Maintenance Vehicles while operating in ATPM or Street Mode using the Driver Assist function described in Section 19.7.

3. The safe train separation function design shall follow the principle of an instantaneous (brick wall) stop of the preceding Train.

4. Safe train separation is based on the supervision and enforcement of the ATP speed profile calculated by the CBTC System.

5. The ATP speed profile shall be calculated as a function of:

    a. Location

    b. Safe braking model

    c. Static System data (e.g., Operating Speed Limits, ends of line)

    d. Variable System data (e.g., temporary speed limits, location of communicating Trains, and Non-Communicating Obstructions (NCOs) deduced by the ZCs.

6. Based on the ATP speed profile calculation, the ATP System shall create the Limit of Authority (LMA) for each Train.

7. The LMA shall be updated continuously to display the distance from current Train location to the LMA on the Train Operator Display (TOD).

8. The ATP functions of the CBTC System shall protect coupling and uncoupling of Trains in CBTC Territory. Coupling and uncoupling requirements are provided in Section 16.3.1.3 (Coupling and Uncoupling).

19.7 SPEED ENFORCEMENT/OVERSPEED WARNING

1. The SFMTA will furnish Contractor with Civil Design Speeds for every section of guideway in CBTC Territory for use in the design of this section. Civil Design Speeds are the safety-critical not-to-exceed speed for that section of the guideway.

2. The System shall include a Configurable non-vital database containing the maximum Operating Speed Limits (OSL) for each section of the guideway.

3. The System shall vitally protect Trains in ATO Territory from an Overspeed Condition and non-vitally protect Trains from an Overspeed Condition in Street Territory.

4. The System shall continuously determine the maximum allowable speed and compare that to the current Train speed.

5. The System shall cut off propulsion and command the necessary braking (up to Full-Service Brake) to ensure that an Overspeed Condition is never reached.

6. In determining the maximum allowable speed, the System shall consider only the Civil Design Speed and the necessary braking to ensure safe stopping in the Limit of Authority (LMA).

7. The maximum operating speed is the highest speed the Train Operator may operate the vehicle in ATPM or Street mode per SFMTA operating rules which consider comfort of ride and other factors. The maximum operating speed shall never be greater than the maximum allowable speed.

8. In determining the maximum operating speed, the System shall consider the maximum allowable speed, the Operating Speed Limit (OSL) for the section of track and any active Temporary Speed Restriction (TSR) on the section of track.

9. The System shall support Civil Design Speed, OSL and TSR definitions with a granularity of 1 MPH.

10. The System shall support Civil Design Speed definitions between 8 and 60 MPH and shall support OSL and TSR definitions between 2 and 60 MPH.

    a. In ATPM Mode and Street Mode, the System shall issue audible and visual warnings to the Train Operator when the actual Train speed exceeds the maximum operating speed.

    b. Contractor shall design and submit for SFMTA approval, specific triggers for these overspeed warnings and a description of the nature and behavior of the warnings/alarms.

    c. The System shall log each occurrence of these warnings/alarms for analysis.

11. The System shall continuously determine the maximum operating speed, compare that to the current Train speed, and non-vitally enforce the maximum operating speed by progressively issuing audible and visual warnings, cutting off propulsion, and braking as defined in this Section.

12. In ATPM mode and street mode, the System shall provide visual indications of the maximum operating speed and the ATS recommended speed on the TOD.

13. The System shall include a Driver Assist function defined as follows:

    a. When the actual Train speed exceeds the maximum operating speed by a Configurable threshold, then the VOBC shall cut off propulsion and apply service brakes to bring the Train speed under the maximum operating speed.

    b. When the actual Train speed is under the maximum operating speed, the VOBC shall release the service brakes and restore propulsion to the Train Operator control.

    c. The Driver Assist function shall only be available in ATPM and Street Mode.

14. The System shall include a Penalty Braking function defined as follows:

    a. When the actual Train speed exceeds the maximum operating speed by a Configurable threshold for a duration exceeding a Configurable time limit, then the VOBC shall cut off propulsion and apply service brakes to bring the Train to a stop.

    b. Once the Train has stopped, the VOBC shall release the service brakes and restore propulsion to the Train Operator control.

    c. The Penalty Braking function shall only be available in ATPM and Street Mode.

15. The Driver Assist and Penalty Braking functions shall be non-vital in Street mode.

16. The System shall allow SFMTA to disable the Driver Assist and Penalty Braking functions for Trains in Street Mode as a System Configuration.

17. The VOBC shall supervise all service brake applications in UTO, ATO, ATPM and Street Modes.

    a. If achieved brake rate is not sufficient to maintain ATP speed profile, the VOBC shall then immediately command a Full-Service Brake application, based on the specific scenario and as per safe braking analysis determination.

    b. If the Train speed continues to increase and exceeds the ATP safe speed by the EB tolerance, the VOBC shall then apply the Emergency brakes (EB).

19.8 INTERLOCKING FUNCTIONS

1. The CBTC System shall provide Interlocking protection for Vehicle movement by regulating, supervising, and reserving switches and routes through Interlockings in CBTC Territory.

2. The CBTC System shall provide route protection, switch protection, overlap protection, flank protection, switch locking and traffic locking to prevent Train collision and derailments.

3. The CBTC System shall not extend an LMA into an Interlocking until the appropriate route is set and locked.

4. If an LMA has been extended through an Interlocking, the affected route shall not be released, and conflicting routes cleared unless either the Vehicle has traveled through and is verified clear of the Interlocking, or the LMA is removed.

5. The CBTC System shall provide manual override functionality to allow Vehicles to pass through an Interlocking, where one or more switches that are part of a flank protection Configuration, are failed or out of correspondence.

6. The CBTC System shall provide functionality for Maintenance and Heritage Vehicles to request routes through Interlockings and receive Interlocking protection.

7. The System shall have Manual Route Authorization (MRA) functionality for Vehicles in CBTC Territory.

8. The Manual Route Authorization (MRA) functionality shall reserve required switches, overlaps, signals, slots, flank protection, and any other Safety Critical restriction required for safe routing of Vehicles in Manual Mode, in the event of failures affecting CBTC onboard systems.

9. The MRA functionality shall have the ability to reserve a minimum of 25 routes per control area at any given time.

10. The removal of Manual Route Authorizations shall be a Critical Command.

19.9 TRAIN DOOR INTERLOCK

1. The VOBC shall supervise Train door opening in CBTC Territory.

2. In ATO Territory, the VOBC shall verify that a Train has arrived at a Berth location before allowing Train doors to open on the correct side, as specified by the database.

3. The VOBC shall determine that the Train is Berthed when the following conditions are met:

    a. The Train is stationary;

    b. The Train is aligned at the stopping point;

    c. The Train steps are in the correct position.

4. Contractor shall define the required accuracy tolerance for Berthing in the System Design Documents.

5. Before allowing Train doors to open, the VOBC shall verify:

    a. The Train is at a stop,

b. Propulsion is disabled,

c. Brakes are applied,

d. Train steps are at the proper level

e. The stepwell warning lights are not flashing

6. The CBTC System shall provide automatic location-based door and step control in Street Territory through the Train door interlock functions.

   a. The VOBC shall command the Train steps to move to the proper level for each stop.

   b. The VOBC shall prevent the opening of specific doors that are not aligned with the designated key stop or platform area.

   c. SFMTA LRVs have front door-only controls. This feature shall account for mini-high platforms where the front door steps must be up and while the steps at the other doors are down.

   d. The CBTC System shall store platform length, required step level and location information for all stops and stations in CBTC Territory to facilitate this feature.

   e. The SFMTA shall be able to designate virtual platform length and location attributes in the system for surface stops with no physical platform.

7. For stops in Street Territory, the VOBC shall compute the manual Berthing accuracy by comparing the position of the Train when the door open command is given to the platform location and dimensions in its database.

   a. The CBTC System shall log this manual Berthing accuracy data and furnish it to the SFMTA Data Warehouse for use in operations management reports.

8. The VOBC shall interlock the Train's door to prevent door opening on the non-platform side of the Train at all stops, even if the Train Operator requests door opening on the non-platform (wrong) side of the Train.

9. The VOBC shall verify that all doors are closed and locked and provide an indication to Train Operator in the operating cab that the doors closed before allowing the Train to depart.

10. The VOBC door interlock shall exclude manually disabled and cut-out doors.

11. The VOBC door interlock shall continue to function with some doors are disabled.

19.10 ROLLBACK PROTECTION

1. Train rollback can be caused by Train failure, manual driving errors, or system errors. The VOBC shall protect against rollbacks and unexpected Train movements.

2. The VOBC shall monitor Train positioning, travel direction and speed to prevent rollback of CBTC equipped Trains as described in this Section.

3. The VOBC shall apply the Emergency Brakes if Train motion is detected against the direction of travel of more than 20 inches.

4. The VOBC shall first use Full-Service Brake to arrest the Train motion before applying the Emergency Brake.

5. The CBTC System shall activate audible and visual alarms on the on the Train's TOD and on the ATS workstations in the Control Center when rollback protection is initiated.

6. The alarms log shall record an event when rollback protection is initiated.

19.11 END OF TRACK PROTECTION

1. The ATP functions of the CBTC System shall provide end of track protection for terminal stations, pockets, sidings, and tail tracks in CBTC Territory.

2. The end-of-track protection function shall prevent Trains from over-traveling the end-of-track or contacting an end-of-track buffer.

3. Contractor shall base their end-of-track protection design on the safe braking model.

19.12 PARTED TRAIN PROTECTION

1. In ATO and UTO Territory, the CBTC System shall provide the functionality to detect and protect parted Trains as follows:

    a. Detection of a parted Train while the Train is at stop shall remove Train's movement authority and keep the Train at stop.

    b. Detection of a parted Train while the Train is in motion shall result in an Emergency Brake application.

2. In Street Territory, the CBTC System may rely on the parted Train detection provided by the LRV4 onboard systems.

3. The System shall activate audible and visual alarms on the on the Train's TOD and on the ATS workstations in the Control Center when a parted Train is detected.

4. The alarms log shall record parted Train detection events occurring in CBTC Territory.

19.13 INTRUSION DETECTION

1. The CBTC System shall prevent CBTC equipped Trains from entering an area of track that is supervised by the Intrusion Detection System when unauthorized access is detected.

2. When the Intrusion Detection System detects unauthorized access, the VOBC shall apply Full-Service Brake to stop all CBTC equipped Trains which are in the area of track where unauthorized access is detected.

3. The CBTC System shall activate audible and visual alarms on the on the Train's TOD and on the ATS workstations in the Control Center when a track intrusion is detected. The alarms log records every track intrusion.

4. Requirements for the interface with the Intrusion Detection system are specified in Section 28 (Interface Management Specifications).

19.14 TUNNEL VENTILATION

1. The ventilation system in Central Subway imposes restrictions on the number of LRVs which may occupy a Tunnel Ventilation Section. SFMTA will provide the definitions of the limits of Tunnel Ventilation Sections and the operational constraints to the Contractor during the System Design Phase. The CBTC System shall prevent CBTC Trains from entering a Tunnel Ventilation Section when the number of LRVs has exceeded the Tunnel Ventilation Section's specified limits.

19.15 AUTOMATIC TRAIN PROTECTION (ATP) FUNCTIONS CDRLS

Table 19-4: ATP CDRL Table

CDRL #	CDRL Title
19.01	ATP System Design
19.02	ATP Software architecture
19.03	Safe Braking Analysis Model
19.04	Train Presence Detection Design

20 MAINTENANCE AND DIAGNOSTIC FUNCTIONS

20.1 PURPOSE

1. This Section specifies the requirements for the CBTC Maintenance and Diagnostic Functions.

20.2 ASSET MANAGEMENT SYSTEM (AMS)

1. The CBTC System shall have an Asset Management System (AMS).
2. The AMS shall receive real-time data from all monitored CBTC subsystems.
3. Each subsystem in the CBTC System shall collect and transmit data to the AMS.
4. The AMS shall store, organize, and provide for analytics and reporting on logs and data supplied by CBTC System.
5. The AMS shall send all diagnostic and maintenance data to the SFMTA Enterprise Asset Management System (EAMS).
6. Such data shall include all inputs required to enable EAMS users to create and manage work orders for preventive and corrective maintenance activities, handle repairs and to manage the inventory of spare parts of the CBTC System.
7. The interface required for the AMS to exchange data with EAMS is specified in Section 28 (Interface Management Specifications) and in the Integration Management Plan.
8. All data collected by the AMS shall be available on the Control Center Maintenance workstations. Contractor shall develop and manage, with input from SFMTA, an Interface Control Document (ICD) that details the data collection and distribution procedures.
9. The AMS shall collect onboard data from the LRV Trainline as specified in the ICD.
10. AMS shall be updated to include the new Equipment delivered as part of each Phase.
11. If duplicate data exists on the Trainline and provided to SFMTA Data Warehouse, Contractor shall not Equip its own sensors on the LRV to collect AMS data.
12. Contractor shall submit an AMS Design Description Document [CDRL] as part of the System Design Documents that includes at least the following information:
    a. Overview of the AMS.
    b. AMS system architecture that describes the CMMS and its internal and external interfaces.
    c. AMS Detail Functionality.
    d. AMS Hardware Specification.
    e. AMS Software Specification.
    f. List of external interfaces required for the AMS to perform the functions described in this Section.
    g. Process and procedures describing methods Contractor and SFMTA shall use to access and utilize the functional interface between AMS and EAMS.

20.2.1 DIAGNOSTIC AND MAINTENANCE DATA

1. Contractor shall define the full list of data collected by the AMS in an AMS Data Document [CDRL].

2. Diagnostic and maintenance data from Control Centers, wayside and onboard subsystems logged by the AMS shall include at least the following:

    a. On-Board Subsystem Data

        i. Equipment Identification.

        ii. Vehicle Location (if known)

        iii. Speed control data.

        iv. Trainlines status.

        v. Check backs status.

        vi. Temperature from sensors on CBTC Equipment.

        vii. Health codes, error codes, and any failure diagnostic data.

        viii. GPS time and coordinates

        ix. System logging data generated by operating systems or application Software.

        x. Power supply logging.

        xi. Self-test results.

    b. Wayside Subsystem Data

        i. Equipment Identification.

        ii. Input/Output pin/port status.

        iii. Interlocking status.

        iv. Temperature from sensors on CBTC Equipment.

        v. Check back status.

        vi. Health codes, error codes, and any failure diagnostic data.

        vii. System logging data generated by operating systems or application Software.

        viii. Power supply logging.

        ix. Self-test results.

        x. Lamp proving status: failed, not failed.

    c. Central Subsystem Data

        i. Temperature from sensors on CBTC Equipment.

        ii. Health codes, error codes, and any failure diagnostic data.

        iii. System logging data generated by operating systems or application Software.

        iv. Power supply logging (via Uninterruptible Power Supply [UPS] for Commercial-Off-The-Shelf [COTS] computers).

        v. Self-test results

d. SFMTA Data

i. Status and logs of external systems as specified in Section 28.

ii. Status and logs available via external interfaces to which CBTC Systems connect

20.2.2 AMS ACCESS

20.2.2.1 AUTOMATIC TRAIN SUPERVISION (ATS)

1. The AMS and ATS subsystem shall have an active connection.

2. AMS alerts for specific alarms shall transfer to the ATS and such alarms shall be displayed on the ATS display.

3. Contractor shall design the list of alarms to be displayed on the ATS GUI [CDRL]. Requirements pertaining to the means of displaying the alarms from ATS is specified in Section 17 (ATS Functions).

20.2.2.2 AMS USER TERMINAL ACCESS

1. Contractor shall deploy a minimum of seven (7) terminals for the AMS, one for each location:

   a. Transportation Management Center (TMC),

   b. Operations Control Center (OCC) Lenox Way,

   c. 700 Pennsylvania, MOW Yard

   d. Muni Metro East (Yard) (MME),

   e. Green shops (2)

   f. Additional location to be specified during the System Design Phase.

2. If additional terminals are required to provide System maintenance, the parties will negotiate a Change Order to procure and configure the additional terminals.

20.2.2.3 AMS REMOTE ACCESS

1. The CBTC shall provide remote access to the AMS to authorized SFMTA personnel from authorized devices (for field personnel) connected to SFMTA's network.

2. Contractor shall install AMS Software on SFMTA-owned laptops to provide remote access of maintenance personnel in the field remote access to the AMS.

3. Contractor shall keep the AMS Software on SFMTA laptops updated and compatible with SFMTA's operating systems and cyber security updates as part of the Support Services.

4. The specifications for secure access to the AMS through SFMTA network are provided in Section 6 (System Safety and Security Management).

20.2.3 AMS DIAGNOSTIC FUNCTIONS

1. The AMS shall automatically analyze diagnostic and logging data supplied by CBTC subsystems to identify failure conditions.

2. The AMS shall issue an alarm in the event of any failures it detects in CBTC subsystems.

3. The AMS shall automatically analyze diagnostic and logging data to predict the component failure in the CBTC subsystems and the failure of devices and systems connected to the CBTC (e.g. UPS units, switches).

20.2.4 AMS MAINTENANCE FUNCTIONS

1. AMS shall interface with SFMTA EAMS as specified in Section 28 (Interface Management Specifications), to maintain an inventory of Line Replaceable Units (LRU), Lowest Line Replaceable Unit (LLRU), Software revision and parts, their status, Configuration, and location.

2. The AMS inventory shall maintain historical data for time in service and repair history for each item inventoried.

3. The AMS shall organize and track the serial numbers for every CBTC LRU and LLRU.

4. The AMS shall have a query and search function that allows users to identify location of the installed LRUs based on their serial numbers.

5. The CBTC Preventive Maintenance (PM) schedule shall ensure the System is maintained in a State of Good Repair and will meet the Reliability, Availability and Maintainability (RAM) Contract requirements.

6. The AMS shall interface with the PM schedule from EAMS to generate alerts and reminders on AMS terminals.

20.2.5 AMS ALARM AND REPORTS

20.2.5.1 AMS ALARMS

1. The AMS shall generate, visualize, store, filter, acknowledge and query alarms in response to abnormal conditions or failures.

2. Contractor shall include a list of AMS alarms and priorities [CDRL] as part of the System Design Documents.

3. The AMS shall send high priority alarms, as designated in the list described in paragraph (2) of this Section, via email/text to SFMTA personnel and via ATS interface to the Transportation Controllers.

20.2.5.2 AMS REPORTS

1. The AMS shall have templates of both graphic and text reports of CBTC maintenance data based on standard SFMTA reporting analytics and dashboards.

2. Contractor shall design the report templates and provide an AMS Reports Description [CDRL] as part of the System Design Documents that specifies the content and layout of AMS report templates.

3. The AMS shall include Software tools which allow SFMTA users to create new data visualizations and reports using AMS data without Contractor involvement.

4. The AMS shall include analytics features and tools which enable end users to develop their own analysis from AMS data.

20.3 NETWORK MANAGEMENT SYSTEM (NMS)

1. The CBTC System shall include a CBTC Network Management System (NMS).

2. The NMS shall manage the entire CBTC Data Communications Subsystem and the CBTC subsystems connected to the CBTC Data Communication System (DCS). Specifications for the DCS are included in Section 26 (Communications).

3. The NMS shall allow a minimum of ten (10) concurrent users without a degradation of performance.

4. The NMS shall report the status of all CBTC network devices (Control Center, wayside, and onboard subsystems) and send all status information to SFMTA. The interface for data and alarms exchanged between NMS and SFMTA systems are described in Section 28 (Interface Management Specifications).

5. Contractor shall submit an NMS Design Description Document [CDRL] as part of the System Design Documents that consists of the following documentation, at a minimum:

    a. Overview of the NMS, including a textual description and architectural schematic(s) detailing all devices and network interfaces to SFMTA CBTC Systems.

    b. NMS Hardware specification

    c. NMS Software Specification

20.3.1 NMS ACCESS

20.3.1.1 ATS

1. The ATS shall monitor connectivity to all required subsystems and raise alarms in the event network connectivity affecting service is disrupted.

2. The NMS shall include more detailed alarms as specified in Section 20.3.2 (NMS Monitoring and Reports).

3. Contractor, using input from SFMTA, shall determine the list of network connectivity alarms to be presented on the ATS.

4. Alarms shall be annunciated as specified in Section 17.5.5 (Fault Reporting and Diagnostic Alarms).

5. The alarm lists specified in this Section shall be included as part of the System Design Documents.

20.3.1.2 FIXED NMS USER WORKSTATION

1. Contractor shall provide a minimum of three NMS Workstations, one for the TMC, one for the OCC and another workstation the location of which will be determined during the System Design Phase. If additional terminals are required to provide System maintenance, the parties will negotiate a Change Order to procure and configure the additional terminals.

20.3.1.3 PORTABLE NMS EQUIPMENT

1. Contractor shall supply SFMTA with five (5) portable NMS workstations with functionality to manage network equipment locally.

20.3.1.4 REMOTE ACCESS

1. SFMTA staff shall be provided remote access to the NMS using authorized devices connected to SFMTA network. Details for secure access of the NMS through the SFMTA network is specified in Section 6 (System Safety and Security Management).

2. The NMS shall connect to SFMTA Data Warehouse and transfer the same information that the NMS Workstation transfers to the Data Warehouse through that connection.

20.3.2 NMS MONITORING AND REPORTS

20.3.2.1 NMS MONITORING AND ALARMS

1. The NMS shall monitor all events for all systems and devices connected to the NMS, including all non-passive devices in the CBTC DCS Network.

2. The NMS shall verify the health and viability of each non-passive device connected to the CBTC DCS.

3. The NMS shall monitor the following devices at a minimum:
    a. Mobile Radios
    b. Base Radios
    c. Cellular modems
    d. Data Cable Network Elements (NEMs)
    e. Office Communications (e.g. LANs)
    f. Office Network Elements (e.g. switches, routers, network traffic irregularities)

4. Contractor shall draft the list of NMS alarms and priorities [CDRL] and include as part of the System Design Documents.

5. The NMS shall distribute specific alarms via email/text to SFMTA personnel.

6. Contractor shall draft a list of specific alarms and SFMTA group/individual to whom these emails/texts will be sent and include it as part of the System Design Documents.

20.3.2.2 NMS REPORTS

1. NMS shall archive all data received or generated into historical database files.

2. The NMS shall extract all saved information and statistics by the following categories, at a minimum:
    a. Date and Time
    b. Device type
    c. Location
    d. Alarm category

3. The NMS data shall cross-reference any of the fields contained in the NMS.

4. The NMS shall report statistics for all CBTC Communications Network parameters using the historical data collected.

5. Contractor shall draft the template for the NMS Reports [CDRL] and include it as part of the System Design Documents.

20.4 MAINTENANCE AND DIAGNOSTIC FUNCTIONS CDRLS

Table 20-22: Maintenance and Diagnostic Functions CDRL Table

CDRL #	CDRL Title
20.1	AMS Design Description Document
20.2	AMS Data Document
20.3	AMS Alarm List for ATS
20.4	AMS Alarm and Priorities List
20.5	AMS Reports Description
20.6	NMS Design Description Document
20.7	NMS Alarm and Priorities List
20.8	NMS Reports Description

21 SIMULATORS AND TOOLS

21.1 PURPOSE

1. This Section states the requirements for the Simulators and other tools used for Development and Testing of the CBTC System.

21.2 SIMULATORS

1. Contractor shall include a Simulators Design Specification Document [CDRL] as part of the System Design Documents that consists of the following information:
    a. Simulators Functional Description.
    b. Simulators Hardware Specification.
    c. Simulators Software Specification
    d. Simulation setup and procedures.
    e. Simulation System Block Diagram.
2. Contractor shall submit a Simulators Manual [CDRL] for SFMTA users and a Simulators Configuration [CDRL] describing the applications and data that the Simulators will use.

21.2.1 TRACTION POWER LOAD SIMULATION

1. Contractor shall provide a Traction Power Load Simulator (TPL Sim), for the purpose of evaluating the ability of the Automatic Train Supervision (ATS) system to manage power loading, and to evaluate the performance impact of proposed power system upgrades.
    a. The TPL Sim shall provide Green CBTC performance evaluations.
    b. The TPL Sim shall operate on virtual machines located in SFMTA's data centers. Contractor may provide the virtual machine infrastructure or may use SFMTA furnished infrastructure.
    c. The TPL Sim shall accept as input a scripted sequence of Train movements to drive the simulation.
        i. The script shall create new Trains from outside the simulated guideway section under simulation and remove a Train when it departs the simulated guideway.
        ii. The script shall create Trains within the simulation section and remove the Train(s) in the simulation section of guideway.
        iii. Trains shall arrive into the simulation section at predetermined speeds.
        iv. The script shall determine the speed target of the Train, the motoring effort, or braking effort commanded for any point in the guideway under simulation.
        v. The simulation shall utilize this input to create the speed and movement profile of the simulated Train.
        vi. The script shall define a path for the Train to follow in the simulation guideway.
        vii. The script shall define movement initiation time for each Train,

viii. The script shall result in a temporal Train movement profile for the purpose of simulation.

d. The TPL Sim shall accept all Consist lengths supported by the CBTC System.

2. The simulation shall configure the Train power characteristics without assistance from Contractor.

   a. Power characteristics shall reflect power draw at different phases of Train operation: start up, cruise, coasting and braking.

   b. Power characteristics shall consider tare, average and crush load factors.

   c. The power consumption characteristics shall accurately reflect the real-life behavior of the LRV4 Trains.

   d. The power consumption shall include the requirements of all systems on the LRV4 Train.

   e. The guideway data set shall contain the physical layout of the guideway.

   f. The data shall include the grades of the guideway.

   g. The guideway simulation shall include resistance to forward motion due to friction, wheel slip due to rail and wheel wear, weather, and other factors.

3. Contractor shall set the output of the TPL Sim to report:

   a. Time tracked sequence of Train movements and the associated power consumption value for movements of individual Trains, and the total power drawn by all simulated Trains.

   b. Time tracked output record of the speed of individual Trains, motoring/braking effort applied, and the instantaneous power consumption of the Train.

   c. Record all events in a combined output file, in an open format.

   d. Capture transient power loading spikes which can result in overloading or damage to SFMTA power equipment.

4. SFMTA will provide information about the existing traction system to the Contractor for the Contractor's use in developing the simulation and associated tools. The Contractor shall request the information needed during the CDR and conduct a detailed field survey after receipt of the SFMTA traction power data to validate existing traction power conditions required for the design.

21.2.2 ONBOARD SYSTEM TEST EQUIPMENT

1. Contractor shall provide Onboard System Test Equipment (OSTE) which emulates the CBTC Central and wayside Equipment for the purposes of testing of CBTC Equipment installed onboard the vehicles.

2. The OSTE shall produce repeatable results across multiple tests with the same starting state and inputs.

3. The OSTE shall emulate wayside communications interfaces to the vehicle and any necessary CBTC System functionality to test the vehicle communications systems and test the full functionality of the onboard systems while in the yard. The OSTE may be installed on a test track.

4. The OSTE shall also support tests of degraded functionality such as by disabling communications radios to simulate a partial or full loss of communications.

5. The OSTE shall be allow the user to input valid or invalid values to any of the wayside and onboard communication fields specified in the Data Communications Interface Control Document and Data Communications Subsystem Interface Control Document (see Section 26) for testing. The OSTE shall calculate and enter correct values for the any fields not input by the user.

6. The ATS Sim shall send ATS commands for field testing without impacting System operations or signaling system networks when real ATS is not available.

7. The OSTE shall record simulation states and communication between simulation and System under test.

    a. The OSTE shall record and log data in open formats for SFMTA analysis and manipulation.

    b. Contractor shall supply Software tools for analysis of the recordings generated by the OSTE.

8. The OSTE shall include a graphical user interface (GUI) as its primary interface.

9. The OSTE GUI shall:

    a. Control all configurations, settings and user input,

    b. Display the output of the OSTE,

    c. Provide a means for the user to download data records and logs and use analysis tools, and

    d. Include a representation of a simulated ATS during any test simulations.

21.2.3 ATS OPERATION SIMULATOR

1. Contractor shall provide an ATS Operation Simulator (ATS OSIM). The purpose of the ATS OSIM is primarily for training of SFMTA Transportation Controllers at the backup Control Center (OCC, 131 Lenox Way).

2. The ATS Operation Simulator (ATS OSIM) shall consist of a Software application that operates on COTS laptops, desktops, and server computers.

3. Contractor shall design and supply the ATS OSIM as a self-installable package that can be installed via a GUI installer on COTS computers using a supported version of Microsoft Windows.

4. Contractor shall provide an ATS OSIM GUI interface for control and operation that can perform the following functions:

    a. ATS OSIM shall start via the GUI interface,

    b. The GUI shall have manual selection of settings required for starting the settings.

    c. GUI shall control all simulation function.

    d. GUI shall have Configuration of the simulator for first start or on new computers.

    e. The ATS OSIM GUI shall display state of the simulator graphically.

    f. The ATS OSIM GUI shall have a help function that provides operation assistance and references to user guides for further assistance in operating the simulator.

5. The ATS OSIM shall have faster than real-time simulation of the CBTC Territory with full complement of SFMTA Trains and other equipped Vehicles.

6. The ATS OSIM shall simulate all CBTC Systems, features and functions so that training of Transportation Controllers replicates real life scenarios.

7. The ATS OSIM shall record the events of a training session and allow for replay of events by the trainer.

8. The ATS OSIM shall have simulation time acceleration and deceleration under control of the trainer.

9. The ATS OSIM shall have simulation time speed of 2x slower than real-time, real-time, 2x real-time, and 5x real-time.

10. The ATS OSIM shall allow the trainer to override any states of the simulation at anytime during simulation to create failure scenarios required for SFMTA training.

11. The ATS OSIM shall have scripted simulation scenarios in which the trainer can load a pre-defined script to configure, control and run the simulation automatically.

12. The ATS OSIM shall record simulation scripts from scenarios manually configured and controlled by the trainer.

    a. Recording shall include any manual inputs to the simulator controls on the trainer and trainee workstations.

13. ATS OSIM shall support a distributed operation where the simulator and/or its components can be loaded onto and operate simultaneously on multiple COTS computers to support training.

    a. The training Configuration shall support up to four (4) Transportation Controllers concurrently.

    b. A single trainer will operate the ATS OSIM to setup and present training scenarios to the trainees.

    c. Contractor shall submit a mock-up of the screen to SFMTA including how dialog boxes will be used throughout the simulation.

    d. All the controls necessary for the trainer to operate the simulator shall fit onto a single screen without overlapping.

    e. The trainer shall have access to a line overview at their workstation.

    f. Contractor shall supply a set of ATS OSIM Software packages to configure the training room computers.

    g. The ATS OSIM package shall include remote desktop management Software to allow the trainer to view and take control of the trainee workstations from the trainer workstation.

14. Contractor shall update the ATS OSIM as needed so that the ATS OSIM is at all times compatible with a supported version of Microsoft Windows for the Contract Term.

21.2.4 ATS PLAYBACK SYSTEM

1. Contractor shall supply an ATS Playback system that enables the user to playback scenarios from both the ATS OSIM and the revenue CBTC System.

2. The ATS Playback system shall incorporate a GUI based Software unit that operates on COTS computers using a supported version of Microsoft Windows.

3. ATS Playback system is controlled via a GUI:
    a. The ATS Playback system shall start up via a GUI initiation.
    b. The GUI shall configure and control the ATS Playback System.
    c. The GUI shall display state of the CBTC System during Playback graphically.
    d. The GUI shall have a help function to display information regarding use of the Software.
4. The ATS Playback system shall provide playback functions for all CBTC System recordings, or partial playback for any single CBTC subsystem exported in a video format.
    a. ATS Playback system shall replay 2x slower than real-time playback, real-time, 2x faster than real-time and 5x faster playback speeds.
5. The ATS Playback System shall display the same GUI as the revenue ATS System.
6. The ATS Playback System shall obtain information from the Asset Management System (AMS) via SFMTA network.
7. The ATS Playback shall use the information obtained from the AMS to playback CBTC recordings.
8. Contractor shall update the ATS Playback System as needed so the ATS Playback System is at all times compatible with a supported version of Microsoft Windows for the Contract Term.

21.2.5 VEHICLE TRAINING SIMULATOR

1. SFMTA will upgrade the existing SFMTA VTSim for the LRV4 Vehicles for the purpose of training the Train Operators on the new CBTC System. Contractor shall provide a functional description and specifications for the VTSim [CDRL] meeting the requirements in this Section to SFMTA so that SFMTA may pass on to its Installer.
2. Contractor shall support the development of the VTSim by responding to RFIs, questions and communications, attending design review meetings and providing clarifications on its functional description and specifications, as described in this Section and in Section 2.5 (Support of Installation Activities).
3. The VTSim will also be used to train the Train Operators in the indications and procedures for surface-level operation in Street Mode and in the subway in ATPM and ATO. The VTSim shall simulate both the surface and the subway environments, displaying all the indications and operations the Train Operator would encounter on a typical journey.
4. The VTSim shall simulate operations in Street Mode, ATPM and ATO modes.
5. The VTSim shall permit Train Operators to practice procedures for the transitions between these modes described in Section 22.6 (Operating Mode Transitions).
6. The VTSim shall simulate CBTC System failures such as loss of communication, where Train Operator action is required.

21.2.5.1 MODE SWITCH SIMULATION

1. The VTSim shall have the same physical buttons, TOD indications, and controls presented in the same location in the simulation as on the LRV4s.

2. The simulation shall present the same System behavior for

    a. transitioning between the ATO and line of sight driving modes using visual stimuli for the driver in the driver display

    b. any associated information lamps in the cab and audio indicators for alarms and warnings that are specified by the CBTC System design.

21.2.5.2 NEW ON-BOARD CONTROLLER SIMULATION

1. Contractor shall design new controls such as resetting the controller and new status displays to replicate the new onboard Equipment fitted to the LRV4 Vehicle.

2. The VTSim shall include the same CBTC displays and indications as are present onboard the LRV, and correctly update them based on an accurate simulation of the onboard Equipment behavior in all modes of Train operation.

3. The VTSim shall simulate normal modes of operation as well as all degraded modes of operation resulting from failures that are likely to be encountered in the actual operating environment.

21.2.5.3 HMI DESIGN AND FAMILIARIZATION USE

1. Contractor shall revise the design specifications and functional requirements for the VTSim prior to each CBTC onboard Equipment Software release to ensure the VTSim GUI, Software and simulation matches the Software in Revenue Service.

21.2.6 SHADOW MODE TEST TOOL

1. For the purpose of Shadow Mode operation, Contractor shall design and provide SFMTA emulation devices to collect Shadow Mode CBTC logs and data to evaluate the performance of LRV4 operating in non-CBTC mode as specified in Section 31 (Testing and Commissioning).

2. The Shadow Mode test tool shall consist of an embedded computer sufficiently small to be installed in the onboard installation area on the LRV4.

3. The Shadow Mode test tool shall connect to the on board, wayside, and other CBTC Systems to record telemetry of the CBTC Systems.

4. The Shadow Mode test tool shall have wireless connectivity to upload collected data to a central repository.

    a. Contractor shall submit the location of this repository to SFMTA for approval.

    b. Contractor shall design and provide the wireless connection as Wi-Fi, 5G/LTE, or proprietary wireless technology.

    c. The wireless connection shall conform to SFMTA cyber security requirements and be protected against unauthorized access.

5. The Shadow Mode test tool shall save to its local memory space the CBTC System data when wireless connection to the central server is not available.

    a. The Shadow Mode test tool shall have sufficient memory to retain data for not less than 7 Days.

b. The data shall upload automatically when wireless connection to the central server has been restored.

6. The Shadow Mode test tool operations shall not interfere with the operation of the CBTC Systems and with the operation of the LRV4, including the legacy ATCS, at any time.

21.2.7 TEST AND DIAGNOSTIC LAPTOPS

1. Laptops for test and diagnostic purposes will be provided by SFMTA. Contractor shall install required Software to SFMTA laptops to allow them to interface with the CBTC System.

2. SFMTA provided laptops with Contractor installed Software shall function as test and diagnostic platforms.

3. The laptops will utilize a standard operating system and will periodically undergo security and Software updates to meet maintainability requirements. Contractor shall ensure its Software is updated to maintain compatibility with a supported version of the operating system for the Contract Term.

21.2.8 SIGNAL SYSTEM EMULATOR

1. Contractor shall provide a Signal System Emulator (SSM) for the purpose of testing and diagnostics of signaling systems installed on the surface.

2. The SSM shall have a Software package with external IO interface module operating on COTS ruggedized laptops. The ruggedized laptops can be the same model as the Test and diagnostic laptops.

3. The SSM shall support interfacing via the IO module to the existing signaling Equipment.

4. The SSM shall emulate required CBTC System outputs that a normally operating CBTC System transmits to the conventional signaling.

5. A user interface GUI shall control all SSM functionality.

6. The SSM shall record the result and data output from any test or diagnostic operations.

   a. The SSM shall display result and data output in the GUI.

   b. The output shall clearly represent the data and results without conflicting or confusing information.

   c. The SSM shall have the recorded result and data downloadable in open formats.

   d. The SSM shall upload the recorded results for storage and later query and analysis.

21.2.9 ZONE CONTROLLER SIMULATOR

1. Contractor shall provide a test device (Zone Controller Simulator or ZCSim) which replicates the function of the Zone Controller for the purpose of testing and maintenance of wayside Equipment. The ZCSim may be an actual Zone Controller or a device designed to simulate a Zone Controller. The ZCSim may be integrated with the maintenance test racks described in Section 21.3.2 (Maintenance Test Racks).

21.2.9.1 INTERFACE REQUIREMENTS

1. The ZCSim shall include a graphical user interface (GUI) as its primary interface.
2. The GUI shall control all configurations, settings and user input.
3. The GUI shall provide a means for the user to download data records and logs, use analysis tools, and display all data and indications to allow a maintenance technician to use the ZCSim to diagnose problems with the connected Equipment.

21.2.9.2 SIMULATIONS

1. The ZCSim shall function and operate in the same manner as a Zone Controller installed as part of the CBTC System.
2. The ZCSim shall simulate its connections to other CBTC Equipment to achieve this functionality.
3. The ZCSim shall provide a means for the user to adjust simulated inputs or parameters so that various failures or operating conditions may be simulated.
4. The ZCSim shall calculate correct values for inputs or parameters that are not input by the user.
5. The ZCSim shall have a default set of inputs and parameters so that the ZCSim functions when the user has not entered any parameters.

21.3 SPECIAL TEST EQUIPMENT AND TOOLS

1. Contractor shall provide all special test equipment required for performing diagnostic and testing of the CBTC System.

21.3.1 PORTABLE TEST EQUIPMENT

1. Contractor shall provide Portable Test Equipment (PTE) for all Control Center, wayside, and onboard subsystems, to aid SFMTA maintenance personnel to maintain, troubleshoot, and repair the CBTC System Equipment.
2. The PTE shall consist of a ruggedized laptop shall include all cables, industrial grade connectors, associated equipment to interface with the test points and any additional special test equipment.
3. Each PTE shall be loaded with all Software necessary to test the CBTC subsystems for which it is assigned, including Control Center, Data Communication System (DCS), wayside, and onboard subsystems.
4. The Contractor shall provide all Software modules, master copy, manuals, and licenses for each PTE program.
5. PTE operations shall not require removal, dislodging, dismounting, or disconnection of any component, card, wire, chassis, terminal, or cables to perform periodic calibration or trouble diagnosis.
6. Embedded diagnostics and annunciations shall detect, diagnose, and isolate CBTC System or CBTC subsystem failures.

7. Contractor shall design and provide the PTE equipment and Software such that using the combination of embedded systems and portable units (PTE), proper operation verification of a subsystem, and troubleshooting of any subsystem failures at both the Line Replaceable Unit (LRU) and Lowest Line Replaceable Unit (LLRU) level is achieved.

8. All test functions to be performed by the PTEs, as required in Section 31(Testing and Commissioning), shall use either a laptop or other PTE.

9. Contractor shall include a Portable Test Equipment (PTE) Design Description Document [CDRL] as part of the System Design Documents that consists of the following documentation, at a minimum:

    a. PTE System Functional Description.

    b. PTE Hardware Specification.

    c. PTE Software Specification

    d. List of functions to be tested by the PTE described.

    e. List of parameters to be tested by the PTE described.

    f. Overview of test setup and procedure.

    g. Test System Block Diagram.

    h. Sample Test Results.

10. Contractor shall provide a sufficient quantity of PTEs to carry out the Maintenance Plan specified in Section 10.5 (Maintenance Plan) and meet Contract requirements.

11. Contractor shall specify the quantity of PTEs to be provided in the Maintenance Plan for SFMTA approval.

21.3.2 MAINTENANCE TEST RACKS

1. Contractor shall provide Maintenance Test Racks to support shop repair and maintenance activities at MME and Green Yards.

2. A Maintenance Test Rack shall have Second Level Maintenance Devices (SLMD) for the purpose of maintenance testing of any CBTC System Line Replaceable Unit (LRU).

3. Contractor shall determine the number of SLMDs to carry out the Maintenance Plan specified in Section 10.5 (Maintenance Plan) and meet Contract requirements.

4. Contractor shall specify the quantity of SLMDs to be provided in the Maintenance Plan for SFMTA approval.

5. Contractor shall submit a Maintenance Test Rack Design Description Document [CDRL] as part of the System Design Documents that consists of the following documentation:

    a. System Functions Description.

    b. Hardware Specification.

    c. Software Specification

    d. List of functions to be tested by the Test Rack.

e. List of parameters to be tested by the Test Rack.

f. Overview of test setup and procedure.

g. Test System Block Diagram.

h. Sample Test Results.

21.3.2.1 PARTITION OF SLMDS

1. Contractor shall provide subsystem specific SLMDs for each component in the CBTC System.
2. Each subsystem SLMD shall test the LRUs contained in the subsystem.
3. Contractor may provide the same SLMD for use on related subsystems.
4. Contractor shall clearly indicate in the Maintenance Test Rack Design Description Document which SLMDs are shared and identify the subsystems they will be shared between.

21.3.2.2 SLMD INTERFACES

1. The SLMDs shall use a GUI that SFMTA maintenance personnel will use to operate the SLMD.
2. The GUI shall control all functions of the SLMDs which do not require physical manipulation of components.
3. SLMD output for test status and results shall be displayed on the SLMD GUI.
4. The outputs shall present important results in plain English and reference to relevant sections of the maintenance manuals.

21.3.2.3 SLMD-LRU CONNECTION

1. Contract shall design SLMDs so that LRUs can be easily installed and removed for testing without hand or power tools.
2. The connectors in the SLMDs shall meet Reliability, Availability and Maintenance (RAM) requirements for extended use combined with repeated connection and disconnection.
3. The SLMD shall allow LRUs to be inserted and removed without damage while the SLMD is powered and operating.

21.3.2.4 TEST AUTOMATION

1. Contractor shall provide pre-configured test routines for the SLMD to perform automatic testing when activated by a single command in the GUI.
2. The SLMD shall present a clear result of the condition of the LRU at the completion of the test routine.
3. The SLMD shall recognize if the incorrect LRU has been attached to the SLMD and provide a warning to the user if this occurs. Incorrect LRU can consist of different Hardware with same connector, or LRUs fitted with a version of Software that is incompatible with the SLMD.

21.3.2.5 TEST SENSITIVITY, ACCURACY AND SPECIFICITY

1. The SLMD shall have predesigned test processes, scripts and procedures sufficiently sensitive to detect partial failure of LRUs, especially for LRUs with analog inputs and outputs.

2. The SLMD shall correctly identify if a LRU has failed to an accuracy of 99.9%.

3. The SLMD test result shall describe the nature of the failure with sufficient detail to allow SFMTA to understand the failure and the action(s) needed to repair the LRU.

4. SLMD test results shall include any data or numerical values to aid this description. For example, if an IO port has failed the SLMD test result must state if the entire port has failed or if only a specific number of IO pins have failed.

21.3.2.6 INTEGRATION WITH ASSET MANAGEMENT SYSTEM (AMS)

1. The SLMD shall automatically log the result of the testing of a specific LRUs in a record of the AMS database, identifying the LRU by type and serial number, and describing the nature of the failure.

2. The SLMD shall have a user interface for querying the AMS for the history of the LRU (by serial number) under testing.

21.3.3 TOOLS

1. Contractor shall provide all tools and Special Tools required to troubleshoot, maintain, and repair each CBTC subsystem. Special tools are specified as tools that are not commercially available from at least three general Hardware Suppliers in the United States.

2. Contractor shall submit a Special Tools Package [CDRL] as part of the System Design Documents.

3. The Special Tools Package shall include, at a minimum:

    a. A list of Contractor approved and recommended tools and Special Tools including, but not limited to:

        i. Vital relay adjustment tools

        ii. Off-the-Shelf Diagnostic Test Equipment

        iii. Special tools required for proper maintenance of the CBTC System, including the onboard CBTC Equipment

        iv. Special tools required for proper extraction of LRU and LLRU (Printed Circuit Board [PCB] extraction)

        v. Special tools required for proper removal of heavy equipment

        vi. Fiber Optic Tool Kit

        vii. LAN network Took Kit

    b. Descriptions of the uses of each tool listed

    c. Quantities of each tool to be provided

21.4 SIMULATORS AND TOOLS CDRLS

1. Contractor shall submit the following CDRLs as part of the Final Design Review package to describe the design and the functionalities of the Tools and Simulators in the scope of this Contract.

Table 21-23: Simulators and Tools CDRL Table

CDRL #	CDRL Title
21.01	Simulators Design Specification Document
21.02	Simulators Manual
21.03	Simulators Configuration
21.04	Portable Test Equipment (PTE) Design Description Document
21.05	Special Tools Package
21.06	Maintenance Test Rack Design Description Document
21.07	VTSim Functional Description and Specifications

22 MODES OF OPERATION

22.1 PURPOSE

1. This Section contains the requirements for the modes of operation functions of the CBTC System. Specific normal and degraded operating modes are specified based on location. Transition requirements between operating modes are specified.

22.2 OPERATING MODES

1. The CBTC System shall have the following operating modes for Trains:
    a. UTO
    b. ATO
    c. ATP Manual (ATPM)
    d. Street Mode
    e. Manual
2. Unattended Train Operation (UTO) Mode.
    a. In UTO mode, the Train shall operate under complete automation without a Train Operator or an attendant.
    b. In UTO mode, the VOBC shall be responsible for all aspects of Train operation including starting and stopping at stations as well as the automatic operation of Train doors.
    c. UTO is only intended to be used for operation of empty Trains at MMT and the tail tracks north of Chinatown station, but the Contractor shall deliver a CBTC System capable of operating Trains in UTO mode anywhere in ATO Territory as long as the conditions described in Section 18.2 are met.
3. Automated Train Operation (ATO) Mode.
    a. In ATO mode, the Train Operator shall be responsible for initiating door closure at each station and initiating motion.
    b. In ATO mode, the VOBC shall be responsible for all aspects of Train operation including starting and stopping at stations as well as the automatic operation of Train doors, as further described in Section 18 (ATO Functions).
4. Automated Train Protection Manual (ATPM) Mode.
    a. In ATPM mode, the Train Operator shall be responsible for driving the Train according to the movement authorizations and indications presented on the TOD.
    b. In ATPM mode, the VOBC shall ensure Automatic Train Protection for the Train, including the enforcement of the movement authority, permanent speed restrictions, and TSRs, along with door interlock functions.
    c. In ATPM mode, the VOBC shall vitally supervise the Train Operator. The VOBC shall continuously calculate a recommended speed based on the maximum operating speed and Train Regulation requirements.

d. In ATPM mode, the VOBC shall provide the Train Operator with indications on the Train Operator Display, including but not limited to:

i. Permitted, recommended and actual speed information

ii. Distance to the next speed restriction

iii. Distance to the next LMA or station stopping point

5. Street Mode.

a. Street Mode is similar to ATPM but is applied on the surface only. In Street Mode, the Train Operator is responsible for driving the Train according to the movement authorizations and indications presented on the TOD and wayside signals.

b. The CBTC System shall non-vitally supervise the Train Operator when the VOBC is in Street Mode.

c. The level of supervision shall be Configurable by the Transportation Controller.

d. The VOBC shall provide Train Door Interlock functions in street mode as described in Section 19.9.

6. Street Mode Configuration options shall include:

a. Driver Assist functions described in Section 19.7 (Speed Enforcement / Overspeed Warning).

b. Penalty Braking functions described in Section 19.7 (Speed Enforcement / Overspeed Warning).

c. Advisory indications on the TOD and logging functions for events where ATP parameters have been exceeded.

7. The CBTC System shall permit all of the Street Mode Configuration options to be active at the same time.

8. When Driver Assist and/or Penalty Braking are enabled, the VOBC shall be capable of cutting off propulsion and commanding service brakes for Trains in Street Mode.

9. Trains in Street Mode with Driver Assist and/or Penalty Braking enabled shall not be permitted to exceed the authorized Limit of Movement Authority.

9. Manual Mode.

a. In Manual mode, the VOBC shall be disconnected from the rolling stock.

b. In Manual mode, Trains shall be driven by the Train Operator on a line-of-sight basis in accordance with instructions from the Transportation Controller. Manual mode Trains are protected by Manual Route Authorizations (MRAs), which provide switch deadlocking and protects the Train from entering a conflicted switch area.

c. Manual mode is rarely used while in CBTC Territory. It is a degraded mode of operation but shall still provide positioning as described in Section 19.3 (Vehicle Location and Speed Determination). It is used to establish the position of a Train after the VOBC is reset or if equipment failure prevents the Train from being driven in a controlled mode.

10. While in Manual Mode and Street Mode, the Train's position shall be tracked in accordance with the requirements in Section 19.3.1 (Vehicle Location and Speed Determination).

11. Heritage and Maintenance Vehicles.

    a. The CBTC System shall have one operating mode for Heritage and Maintenance Vehicles meeting the requirements in Sections 2.4.2 and 2.4.3.

    b. The Contractor shall design a means to turn off the CBTC Equipment in Heritage and Maintenance Vehicles.

22.3 NORMAL OPERATING MODES AND TERRITORIES

1. CBTC Territory includes two basic types, as described in Section 2.2.2. surface and subway. For normal operation, a specific operating mode shall correspond to each type of CBTC Territory.

2. The availability of specific operating modes within portions of CBTC Territory are:

    a. UTO.

        i. UTO mode shall only be available in ATO Territory and on dedicated ATO test tracks in the Green and MME rail yards.

        ii. The normal operating mode in UTO Territory shall be UTO.

        iii. In normal operations, UTO will be used only in UTO Territory and not in ATO Territory.

    b. ATO.

        i. ATO mode shall only be available in ATO Territory and UTO Territory, except as described in this paragraph.

        ii. ATO mode shall be available on dedicated ATO test tracks in the Green and MME rail yards.

        iii. The normal operating mode in ATO Territory shall be ATO.

        iv. ATO mode shall not be available outside of ATO Territory and test tracks.

    c. ATPM. ATPM is a degraded operating mode in ATO Territory. Refer to Section 22.4.

    d. Street Mode. The normal operating mode in Street Territory shall be Street Mode.

3. Manual mode is the normal operating mode outside of CBTC Territory.

22.3.1 SUBWAY LOCATIONS

1. ATO Territory shall be defined as all subway areas described in Section 2.2.2, except:

    a. UTO Territory and,

    b. The Eureka shooflys leading from a junction just west of Castro station to the surface via a locked gate. The Eureka shooflys are for Maintenance Vehicle access only.

2. UTO Territory shall be defined as:

    a. Muni Metro Turnback Facility (MMT) in the Market Street Tunnel east of Embarcadero Station, as described in Section 22.3.1.1 (Muni Metro Turnback).

b. Central Subway tail tracks located north of the Chinatown station platform, as described in Section 22.3.1.2.

22.3.1.1 MUNI METRO TURNBACK

1. The Muni Metro Turnback (MMT) contains three pocket tracks – Far, Center, and Near – for turnback operations. The center pocket is not frequently used due to car length. These pocket tracks are located in between the two mainline tracks. All MMT pocket tracks shall be Berthing locations.

2. Trains with a final destination of Embarcadero Station travel out of service beyond Embarcadero station to utilize the pocket tracks to switch back and return to the westbound Embarcadero platform. For normal operation, non-revenue Trains traveling between Embarcadero Station and one of the pocket tracks shall operate in either ATO or UTO.

3. Revenue N Judah Trains traverse the mainline tracks through the MMT between Embarcadero Station and the Ferry Portal to the surface tracks while other Trains are switching back. Revenue service Trains between Embarcadero Station and Ferry Portal shall operate in ATO.

22.3.1.2 CENTRAL SUBWAY TAIL TRACKS

1. Central Subway contains two tail tracks adjacent to and immediately north of Chinatown platform. These tail tracks are used to store additional Trains to be used as gap Trains for line management, to stage Trains for special event service, or to store malfunctioning Trains until the end of the service day. The tail tracks are not used in normal operations but shall be Berthing locations.

2. Trains terminating at Chinatown shall be routed to the western platform (Platform 1) by default.

3. If Platform 1 is full, Trains shall be routed to the eastern platform (Platform 2). Trains generally resume service southbound in a First In, First Out order when operating in Headway Management mode, although the order may be manually altered by controllers by modifying the platform Dwell Time as specified in Section 17.6.4 (ATS Station Bypass and Manual Control of Dwell).

22.3.2 SURFACE LOCATIONS

1. Street Territory shall be defined as the portions of CBTC Territory described in Section 2.2.2 that are not designated as ATO or UTO Territory in Section 22.3.1 (Subway Locations).

22.3.3 YARD LOCATIONS

1. Yard locations are not included in CBTC Territory, unless specific yard track has been identified in the Design Phase and agreed between the Parties as necessary to perform fit-for-service checks during the pull-out. The normal operating mode in the yards is Manual mode.

2. Yard Test Tracks are not considered CBTC Territory but UTO, ATO, ATPM and Street Mode may be used on Test Tracks for testing purposes.

3. Manual movement permissions, routes and destination will be transmitted to the Train Operator via radio messages.

22.4 DEGRADED OPERATING MODES

1. Manual mode shall always be considered a degraded operating mode anywhere in CBTC Territory.

22.4.1 SUBWAY LOCATIONS

1. In UTO Territory, when UTO mode is not available, the Trains shall operate in ATO, ATPM or Manual.

2. In ATO Territory, when ATO Mode is not available, the Trains shall operate in ATPM or Manual.

3. Operations in ATPM in ATO Territory or UTO Territory shall be considered a degraded mode of operation.

22.4.2 SURFACE LOCATIONS

1. When Street Mode is not available, the Trains shall operate in Manual.

22.4.3 LOSS OF COMMUNICATIONS

1. A Train that has lost communications with the CBTC or has a positional uncertainty greater than the dynamic position uncertainty limit described in Section 19.3 (Vehicle Location and Speed Determination) is a “Non-Communicating Train" (NCT) and shall be treated as an emergency.

2. When a Train experiences a loss of communications with the CBTC or the dynamic position uncertainty of a Train has increased beyond the dynamic position uncertainty limit described in Section 19.3, the CBTC System shall:

    a. In ATO Territory or UTO Territory, display an audible and visual alert to the Train Operator and stop the Train using Full-Service Braking.

    b. In Street Territory, display an audible and visual alert to the Train Operator and hold the Train at the next platform or stop.

    c. Display an audible and visual alarm on the ATS GUI and the AMS consoles.

    d. Mark the last known and estimated position of the Train on the ATS GUI. NCT shall be tracked by both ZC and ATS.

    e. In ATO Territory or UTO Territory, close tracks around the last known and estimated positions of the Train.

    f. Hold the Train in position until communications are restored or Train Operator acknowledges the loss of communications alarm.

    g. Not allow Train movement until “Manual” mode is selected in the cab.

    h. Restore full CBTC functionality automatically upon regaining communications and announce this condition on the TOD. The Train Operator will initiate recovery by selecting ATO/Street or ATPM/Street on the mode selection switch.

3. The ATS shall track the Consist ID associated with the NCT and continue to show the best available position of the NCT, which can be either:

    a. The last known position

    b. The estimated position based on the last known position, speed and direction of the vehicle

    c. A real-time position based on a non-vital positioning system, such as GPS, as described further in Section 19.3 (Vehicle Location and Speed Determination).

4. The ZC shall create a Non-Communicating Obstruction (NCO) area of protection envelope associated with a communicating Train (CT) when the CT loses communication with the ZC for a specified time duration.

5. The envelope shall be from the last reported position of the Train up to its Limit of Movement Authority (LMA).

6. When an existing NCO is within or adjacent to a Manual Route Authorization (MRA), the NCO shall extend along the MRA until another NCO or obstruction is detected along the MRA path.

7. The ZC shall track and update the Non-Communicating Obstruction (NCO) created based on the best available NCT position.

8. An NCO area associated with an NCT shall be removed when the NCT regains communication with the ZC or when a communicating Train travels through the existing NCO area in Manual mode in an operational procedure known as sweeping.

9. An NCO area with no association to an NCT shall be removed when:

    a. A communicating Train has swept through the NCO area.

    b. For cases involving territory boundaries, a communicating Train can be assumed to have swept an NCO area behind the Train outside of the boundary.

    c. A secure command has been entered into the ATS GUI to clear an NCO created by a Maintenance Vehicle leaving the guideway as described in Section 16.3.1.1 (Entering/Exiting CBTC Territory).

10. The ATS subsystem shall permit Transportation Controllers to clear last known and estimated position markers to enable resumption of normal operations once the Non-Communicating Train has been moved. Non-Communicating Trains will be taken out of service and proceed to a yard or siding in Manual operation, with the Transportation Controllers communicating to the Non-Communicating Train and other nearby Vehicles using voice radio, and using ATS GUI commands to keep communicating Trains away from the Non-Communicating Train's reported position.

22.5 Operating Mode Selection

1. The System shall incorporate a physical mode selection switch located in each cab of each LRV to select the operating mode of the VOBC.

2. The VOBC shall support the seamless automatic transitions between street and subway modes and transitions triggered by a change in the position of the mode selection switch as described in Section 22.6 (Operating Mode Transitions).

3. The following positions shall be defined for the mode selection switch:

    a. UTO

    b. ATO / Street

    c. ATPM / Street

    d. Manual

4. The CBTC System shall provide a visible indication of the current Train operating mode on the TOD at all times.

5. The CBTC System shall regulate the operating modes that may be selected based on location, System Configuration, and Equipment status as described in these Contract Specifications.

6. The CBTC System shall not change to a prohibited or not available operating mode if it is selected by the Train Operator.

7. If the mode selection switch is set to a position corresponding to a prohibited or not available operating mode, the TOD shall display a message indicating that the selected mode has not been activated and the reason (such as "Not Available", "Outside ATO Territory," or the code of the fault preventing the transition).

8. The CBTC System shall trigger visible and audible alarms in the Train Operator cab when the operating mode selected using the mode selector switch does not agree with the current Train operating mode.

22.6 OPERATING MODE TRANSITIONS

22.6.1 TRANSITIONS BETWEEN UTO AND ATO, UTO AND ATPM

1. The CBTC System shall only allow transitions to UTO mode when the Train is Berthed at an Embarcadero or Chinatown platform, Mode selector in UTO and the Automatic Turnback function is activated as described in Sections 22.3.1.2 and 22.3.1.3.

2. In the event of a malfunction, intruder, or the Automatic Turnback feature being disabled while a Train is in UTO, the CBTC System shall permit a Train Operator to board an unattended Train that has been stopped as described in Sections 22.3.1.2 and 22.3.1.3 to recover the Train. Once onboard, the Train Operator will select ATO or ATPM mode to transition from UTO mode.

3. The CBTC System shall prevent a Train in UTO mode from leaving the Embarcadero westbound platform or either Chinatown platform in the southbound direction until ATO or ATPM mode is selected.

22.6.2 TRANSITIONS BETWEEN ATO AND STREET MODE

1. Mode transitions from ATO to Street Mode and from Street Mode to ATO shall occur with the Train in motion at Duboce Portal, Ferry Portal, Bryant Portal and at both Sunset Tunnel portals.

    a. While the Train is in Street Mode and the mode selector switch is in the ATO / Street position, the VOBC shall automatically transition the Train to ATO mode without stopping as it enters ATO Territory in these locations.

    b. When a Train is in ATO mode and is leaving ATO Territory at these locations, the VOBC shall prompt the Train Operator via the TOD to acknowledge the upcoming transition to Street Mode with a visual and audible warning.

    c. If the Train Operator does not provide an acknowledgment, the VOBC shall service brake the Train to a stop before the transition point.

    d. Once the Train Operator has acknowledged the transition, the VOBC shall put the Train into a coast condition at which point the Train Operator will be required to initiate manual driving.

e. The TOD shall display a distance to go to the transition point, which will be updated at least every second.

2. Mode transitions from ATO to Street Mode and from Street Mode to ATO shall occur with the Train Berthed at the platform at West Portal Station.

   a. At West Portal Station, the transition from Street Mode to ATO mode shall take place automatically when the mode selector switch is in the ATO / Street position and the Train begins Dwelling at the platform.

   b. At West Portal Station, the transition from ATO Mode to Street Mode shall take place when the Train is Dwelling at the platform and the VOBC has received a movement authority out of the subway. If the VOBC is commanded to reverse and receives a movement authority back into the subway, it will remain in ATO mode.

3. Transition points shall be located at each ATO Territory boundary as defined in Section 22.3 (Normal Operating Modes and Territories).

4. The Contractor shall describe the specific procedures for each transition in the System Design Documents.

22.6.3 TRANSITIONS BETWEEN MANUAL AND ATPM/STREET MODE

1. The transition from Manual to ATPM mode shall operate only in ATO Territory.

2. The transition from Manual to Street mode shall operate only in Street Territory.

3. The transition from ATPM or Street Mode to Manual shall operate with the Train at stop.

4. The CBTC System shall activate a visible and audible alarm if the Train is not in Manual mode when departing CBTC Territory.

22.6.4 ENTERING AND EXITING CBTC TERRITORY

1. The Contractor shall design transition areas where Vehicles transition between the yards and CBTC Territory.

2. Transition areas between the yards and CBTC Territory shall not be on revenue track or otherwise interfere with Trains in Revenue Service.

3. Heritage Vehicles will transition between CBTC Territory and the Heritage Vehicle-only surface tracks described in Section 2.2.2 (CBTC Territory) paragraph 4a and 4b. The Contractor shall design transition areas where Heritage Vehicles make these transitions.

4. Due to the phased implementation of the project, Vehicles will transition into and out of CBTC supervision at boundaries between portions of CBTC Territory where the System has been Commissioned and phases where the System is inactive. Contractor shall design temporary transition areas at these boundaries and include in the Project Schedule the time periods during which the temporary transition areas will be used.

5. The precise locations of the transition areas described in this Section shall be included in the System Design Documents. SFMTA will approve the locations, boundaries, and limits of the transition areas as part of the Design Review Process.

6. For transitions entering CBTC Territory, Trains shall start in Manual and transition to Street Mode.

7. For transitions exiting CBTC Territory, Trains shall start in Street Mode and transition to Manual.

22.7 MODES OF OPERATION CDRLS

1. Contractor shall include a CBTC Operating Modes document [CDRL] that describes how the System shall comply with the requirements specified in this Section as part of the Preliminary Design Review package.

Table 22-24: Modes of Operations CDRL Table

CDRL #	CDRL Title
22.1	CBTC System Operating Modes

23 RESERVED

24 ONBOARD SUBSYSTEM

24.1 PURPOSE

1. Section 24 contains the requirements for the CBTC onboard subsystem for LRVs.

24.2 INTRODUCTION

1. SFMTA currently operates three different classes or types of rail vehicles within CBTC Territory:
    a. Heritage fleet
    b. Breda LRV 2/3 (being retired, will not be equipped with CBTC System)
    c. Siemens LRV4
2. Contractor shall integrate the CBTC System with the Siemens LRV4 onboard systems so that the CBTC controls those Vehicles as specified in this Agreement.
3. The LRV4 fleet is currently equipped with the Contractor's SelTrac IS ATCS Vehicle onboard Controller (VOBC) equipment that performs the Automatic Train Protection (ATP) and Automatic Train Operation (ATO) functions in the Market Street Subway and Central Subway.
4. The CBTC onboard Equipment shall perform ATP, ATO and Train to Wayside Communication (TWC) functions as described in Sections 16, 17, 18, 19, 22, 26 and 27.
5. Contractor shall perform System integration activities that verify and validate the functionality of the CBTC onboard Equipment and the LRV's subsystems to provide a fully functional CBTC onboard subsystem that operates as specified in all modes of operation described in Section 22 (Modes of Operation).

24.3 GRADES OF AUTOMATION AND OPERATING MODES

1. The CBTC System shall operate LRVs in the following Grades of Automation, as defined in IEC 62290-1:2014, corresponding to the operating modes described in Section 22.2 (Operating Modes):
    a. GoA4 – Unattended Train Operation (UTO)
    b. GoA2 – ATO Semi Automated Train Operation (STO aka ATO)
    c. GoA1 – Non-Automated Train Operation (ATP Manual and Street)
    d. GoA0 – Line of Site Operations (Manual)
2. The Contractor shall design and provide a mode selector switch with four positions so that the Train Operator may select an operating mode as described in Section 22.5 (Operating Mode Selection).

24.4 VITAL/NON-VITAL FUNCTIONS

1. The Vital and non-Vital onboard CBTC functional requirements are specified in Section 16, 18 and 19.

24.5 ONBOARD SUBSYSTEM INTERFACES

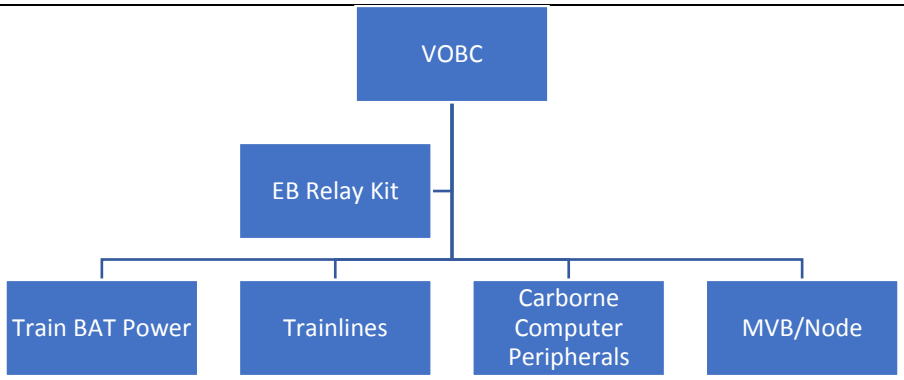
1. In collaboration with SFMTA and Siemens, Contractor shall develop an CBTC onboard subsystem and Vehicle Interface Control Document (ICD)[CDRL] for the CBTC onboard subsystem and Vehicle interfaces.

2. The ICD shall cover all mechanical, functional and electrical interfaces between the CBTC System and the LRV onboard systems including, but not limited to, interfaces identified in this Section 24.5.

24.5.1 EXISTING ONBOARD LOGICAL INTERFACE ARCHITECTURE

1. The existing VOBC System architecture is represented in Figure 24-1.

Figure 24-3: Existing onboard subsystem Architecture



2. The new CBTC onboard subsystem shall have a design that maximizes reuse of the current interfaces and minimizes Train modifications.

24.5.2 TRAINLINES

1. The CBTC onboard subsystem design shall maximize the reuse of current Vital and non-Vital Trainlines. The electrical interface between the existing ATCS and the Vehicle Trainlines is described in the Reference Documents.

24.5.3 MULTIFUNCTION VEHICLE BUS

1. The Multifunction Vehicle Bus (MVB) is the current interface between the ATCS VOBC and the Siemens Train Management Software System for non-Vital functions. The CBTC onboard subsystem design shall interface with the MVB for non-Vital functions.

24.5.4 HUMAN MACHINE INTERFACE (HMI)

1. The CBTC System shall interface with the LRV4 Siemens Train Operator Display (TOD) to display at least the following information:

    a. Selected Train operating mode and available operating modes

    b. Current Vehicle speed

    c. Maximum Vehicle speed for the track section where the Train is currently operating

d. Next (immediately approaching) speed limit and distance to the track section where the speed changes

e. Speed at which penalty braking will be initiated

f. Recommended speed to maintain headway and schedule based on the train regulation mode in effect for the Service Line (See Section 17.5.1.4).

g. Distance to Limit of Authority (measured in feet)

h. Next station, signal, or Junction ahead, and status (e.g. switch position, signal aspect)

i. Next Work Zones, Temporary Speed Restrictions (TSR)

j. Vehicle Door status

k. At stations, Dwell Time count down

l. At stations, recommended Dwell Time to maintain headway and schedule based on the train regulation mode in effect for the Service Line (See Section 17.5.1.4).

m. At stations, readiness to depart

n. Limiting factor for LMA (example signal, CBTC exit, end of track, station stop)

o. CBTC Entry/Exit

p. Train hold, Countdown time remaining on hold

q. Station Bypass

r. Platform Berthing status (proper Berthing, overshooting, undershooting)

s. Vehicle Position

t. Consist ID / Block ID (Train identification number)

u. Current Time

v. Braking status

w. Active CBTC or Train equipment faults

x. System alarms and indications as required in these Specifications

2. The above list is not complete. The Contractor shall complete the above list and submit the completed list along with the TOD layout and a description of how the display information will be presented in various operating modes, validated by Human Factor Analysis [CDRL], as part of the System Design Documents.

3. Siemens will perform the TOD software modifications in accordance with the approved CBTC onboard subsystem and Vehicle Interface Control Document (ICD) [CDRL] and Human Factor Analysis [CDRL]. Requirements in these Contract Specifications which make reference to TOD display or functionality shall be interpreted as requiring the Contractor to design its System and its interface to the TOD enabling the described display or function.

4. SFMTA will contract with Siemens to perform the TOD software modifications and Contractor shall support this integration effort as described in Section 2.6 (System Integration Services) and Section 4.3.6 (Integration Management Plan).

24.6 ONBOARD SUBSYSTEM DESIGN

1. Contractor shall design the CBTC onboard subsystem, integrate it with the Vehicle Equipment and subsystems, and provide all Equipment, connectors, and cabling for the CBTC System interface.

2. The LRV4s are 75 feet long and they are designed to operate in Consists between one and four cars. The CBTC onboard subsystem shall operate in any Consist configuration of one, two, three or four cars.

3. Contractor shall design and supply a new mode selection switch in the cab to select the modes of CBTC operation as described in Section 22.5 (Operating Mode Selection).

4. Contractor shall design and supply an ATO Start Button in the cab which is used to continue Automatic Train Operation in ATO mode between the station stops as described in Section 18.2 (General ATO Specifications).

5. All CBTC onboard Equipment products shall comply with the Hardware requirements specified in Section 27 (Equipment Requirements).

6. All CBTC onboard Equipment shall meet the Reliability, Availability, and Maintainability (RAM) requirements as specified in Section 30 (Reliability, Availability, and Maintainability).

7. The onboard System architecture shall meet all the requirements in these Contract Specifications.

8. Maintenance personnel onboard the Train shall access the CBTC onboard subsystem's self-test diagnostics, notifications/alarms, and logs via test laptop.

9. The CBTC System shall report failures and out-of-tolerance conditions that can impact CBTC functionality to the Siemens TOD.

10. Contractor shall develop a maintenance plan and maintenance manuals for the CBTC onboard Equipment as specified in Section 10.

11. Contractor shall develop a training plan, provide training materials, and provide training for CBTC onboard Equipment in accordance with Section 11.

12. The maximum weight limit per car for a complete set of CBTC onboard, undercar Equipment and cables, excluding enclosures, shall not exceed 400 lbs.

13. The Contractor shall design the CBTC onboard systems so that any VOBC in a Consist of two or more vehicles may be used as the active VOBC in control of the Consist.

14. Should the active VOBC in a Consist fail, one of the remaining VOBCs shall take control of the Consist as the active VOBC automatically and seamlessly, with no single points of failure.

15. All VOBC failures shall be presented and logged in the AMS.

24.7 ONBOARD INSTALLATION

1. Contractor shall supply all design, installation plans, procedures, and test requirements for successful installation of the On-Board CBTC Equipment. The direct installation work is not part of Contractor's scope and will be performed by an Installer.

2. The Installer will warrant all installation work completed on the LRVs. Contractor shall perform Quality Control oversight as described in Section 8.5.1.2 (Vehicle Installer).

3. Contractor shall survey the existing LRV fleets and identify space for CBTC onboard Equipment.

4. The installation of the CBTC onboard Equipment shall have easy access for maintenance and shall not obstruct the maintenance of other components and systems of the car.

5. Contractor shall identify any modifications to the LRVs necessary to support Equipment installation and include those modifications in its Vehicle Installation Plan.

6. Contractor shall supply a Vehicle Installation Plan [CDRL], as required in Section 8.5.1.2 (Vehicle Installer), and provide detailed Vehicle Installation Procedures [CDRL] for the CBTC onboard Equipment to be used by SFMTA and Installers.

7. Contractor shall develop and execute a comprehensive Vehicle Test and Acceptance Plan [CDRL] and produce Vehicle Test Procedures and Test Reports [CDRL] for all CBTC onboard Equipment, including Post Installation Check-Out (PICO), static, dynamic and System integration tests on all Trains as detailed in Section 31.

8. The Contractor shall develop a robust Quality Control program in accordance with Section 5 (Quality Assurance and Quality Control) such that the Contractor will either accept Vehicles or submit a Vehicle Punch List within the times prescribed in the Project Management Plan.

24.8 ONBOARD MIGRATION

1. The Migration from the existing ATCS onboard equipment to the new CBTC onboard Equipment shall not impact SFMTA's Revenue Service operations.

2. Through the Migration process, SFMTA shall always have sufficient LRVs available for scheduled Revenue Service.

3. Contractor shall integrate the CBTC onboard Equipment with the LRV systems and test the new CBTC System without affecting existing ATCS equipment functionality.

4. The CBTC shall not disturb any ATCS functions until after Subway Cutover.

5. To facilitate migration until the ATCS is decommissioned, Contractor shall design the new CBTC on-Board Equipment such that the Train will operate with either the ATCS or the CBTC, depending on the system selected.

6. Contractor shall design, Furnish and test a temporary mechanism or function for the Train to switch between using the CBTC and the legacy ATCS for testing and during the Pilot Operating Period. This function may work with or without a Train Operator action.

7. During the Pilot Operating Period, Trains will have to switch between the two systems multiple times a day while in Revenue Service. The details of this function and associated operating procedure shall be included in the On-Board Migration Plan [CDRL] for SFMTA review and approval. The temporary mechanism or function shall be removed from the LRVs after Subway Cutover.

8. As part of the Migration strategy Contractor may install a temporary switch in the LRV cabs that will allow the Train Operator to switch from the CBTC System to the existing ATCS in sections where the CBTC System is not installed and certified, and to switch from the ATCS to the CBTC System in sections where the CBTC has been installed and certified for Revenue Service.

9. Contractor shall produce designs for both the dual-equipped (ATCS and CBTC) configuration and the final CBTC onboard subsystem configuration (after Subway Cutover) and include these as part of the Onboard Migration Plan.

10. Contractor shall develop procedures for removal of any temporary Equipment and provide instructions for decommissioned ATCS onboard equipment removal as a condition of Subway Cutover.

11. Contractor shall submit a CBTC On-Board Migration Plan [CDRL] as part of the Preliminary Design Review package for SFMTA approval.

12. Contractor may propose an alternative Migration strategy to that described in this Section 24.8 in a draft of the CBTC On-Board Migration Plan. The SFMTA will reject Migration strategies that negatively affect the transit operations.

24.9 ON-BOARD CDRLS

1. Contractor shall develop an Onboard Subsystem and Vehicle Interface Control Document (ICD) [CDRL] as described in Section 24.5.

1. Contractor shall provide detailed technical descriptions of CBTC onboard subsystem Equipment and components, including Equipment Functional Specifications (EFS) [CDRL] and On-Board Design Descriptions [CDRL].

2. Contractor shall provide a TOD Graphical User Interface (GUI) specification [CDRL] and Train Operator Display Human Factor Analysis [CDRL] that specifies the human machine interface graphics for the CBTC information on the Train Operator Display.

3. Refer to Section 27 for Hardware Design CDRL requirements.

Table 24-25: On-Board CDRL Table

CDRL #	CDRL Title
24.01	CBTC onboard and Vehicle ICD
24.02	Train Operator Display Human Factor Analysis
24.03	Vehicle Test and Acceptance Plan
24.04	Vehicle Installation Procedures
24.05	Vehicle Test Procedures and Reports
24.06	CBTC onboard Equipment Migration Plan
24.07	CBTC onboard Equipment Functional Descriptions (EFS)
24.08	CBTC onboard Design Descriptions
24.09	Graphical User Interface (GUI) Specification for Train Operator Display

25 RESERVED

26 COMMUNICATIONS

26.1 PURPOSE

1. This Section contains the requirements for the CBTC Data Communications Subsystem.

26.2 GENERAL

1. This Section provides an overview description of the Data Communications Subsystem (DCS) which provides all required CBTC Communications functionality. This overview describes and specifies labor, Materials, tools, Equipment, Software, Hardware, and incidentals necessary for Contractor's design, furnishing and Support for installation of a Data Communications Subsystem.

2. Contractor shall include in its designs all communications elements and components necessary for a complete and operable CBTC System that meets all Contract requirements.

3. The omission of any element or component of the CBTC Communications Subsystem from these Specifications shall no excuse Contract from including said omitted elements or components in its System design.

4. Contractor shall supply a Data Communications Subsystem that utilizes communications subsystems, elements, components, networks, and ancillary devices as required to supply a complete, comprehensive CBTC Communications System meeting all the requirements of the Contract Documents.

5. Contractor shall submit a DCS Design Document [CDRL] describing the DCS functions and architecture, as part of the Preliminary Design Review package.

6. All CBTC System elements requiring network connectivity shall interface and interconnect through the Data Communications Subsystem, whether the CBTC System elements are supplied by Contractor or provided by SFMTA.

7. Contractor shall design the Data Communications Subsystem as an integrated a set of communications sub-systems.

8. The DCS shall have network connectivity between CBTC System elements including, but not limited, to Interlockings, crossings, Vehicles, Control Centers and CBTC regions.

9. Design of communications and network infrastructure shall comply with SFMTA Requirements for Technology Projects provided in Appendix J to the Agreement.

10. Contractor may make use of certain existing SFMTA wayside communications resources as part of their design. Contractor shall review the existing SFMTA IT infrastructure and equipment available for possible utilization in the CBTC design.

11. Contractor shall determine via inspection and document review during the System Design Phase what, if any, existing SFMTA infrastructure or equipment is suitable for incorporation into the DCS.

12. Contractor shall also clearly identify gaps in SFMTA's existing communications infrastructure that must be addressed to achieve Contractor's design and propose action (such as the installation of additional underground fiber optic cable in specific locations) for SFMTA.

13. Contractor shall collaborate with SFMTA during the System Design Phase to identify the specific resources that SFMTA will make available to Contractor.

14. Contractor shall clearly identify in all design submittals the intent to utilize any SFMTA-furnished communications elements.

15. Contractor shall supply additional wayside communications resources if the existing SFMTA resources are not sufficient to meet the Contract requirements. See Section 9 for SFMTA Furnished Items requirements.

16. Existing communications resources that may be available for use by Contractor include:

    a. Existing dark (unused) wayside fiber optic cable. Dark fiber strands exist along many sections of SFMTA right-of-way interconnecting wayside and facility locations including the primary and back up Control Centers. SFMTA will close gaps in its fiber optic network as needed to support the CBTC Project.

        i. Contractor is responsible for testing all dark fibers they plan to use in their design to verify fiber performance prior to connecting any active CBTC Equipment to the Fiber Distribution Panels (FDPs).

        ii. Contractor shall design and provide all installation and testing documentation for all devices that may utilize existing SFMTA dark fiber optic cable.

        iii. Contractor shall supply the fiber optic equipment and peripherals that are used to connect Contractor's CBTC Equipment to SFMTA's dark fiber and Fiber Distribution Panels (FDP)

    b. Existing rack space in wayside cases and houses on SFMTA right-of-way.

    c. Available conduit and pull boxes on SFMTA right-of-way.

    d. Existing SFMTA facility rack space, floor space and communications resources such as cable trays and raceways.

17. Contractor shall clearly identify in Contractor’s design submittals the proposed use of SFMTA’s existing communications infrastructure.

18. Contractor shall configure and interconnect their CBTC System to interface with existing SFMTA communications subsystems as required for CBTC functionality.

19. All cabling shall be properly labelled and tied for maintenance use.

20. Contractor shall not interrupt or disturb existing SFMTA communications without prior notification and approval by SFMTA.

21. Contractor shall supply the material and installation instructions for any components installed as part of Contractor's utilization of SFMTA communication resources including, but not limited to, any additional cards, chassis, power supplies or interface devices, fiber patch and termination panels, or fiber optic jumper cables.

22. Contractor shall provide design support and oversight for any modification to existing SFMTA communication resources identified by Contractor in its design that will be performed by SFMTA staff or Installers.

23. Contractor shall collaborate with SFMTA to develop the configuration of CBTC-related network equipment including assignment of IP addresses, subnetting configuration, and security strategy.

24. Contractor shall submit the IP Addressing Scheme [CDRL] for SFMTA approval.

25. The Data Communications Subsystems shall interconnect, at a minimum, the following CBTC System elements:

    a. Office Systems (in the primary and backup Control Centers, and any other office System location called for in these Contract Documents):

    b. Wayside Systems:

        i. Zone Controllers (ZC).

        ii. Wayside wireless data radios/modems

        iii. Signal controllers

        iv. Grade crossings

        v. Network switches

        vi. SCADA/Access control devices

    c. Vehicle Systems:

        i. All Vehicle communications equipment

    d. CBTC Network Management System (NMS).

    e. CBTC Network Security System (NSS).

26. Contractor shall supply a functional Data Communications Subsystem that includes, at a minimum, the following major sub-systems, as required for a complete and comprehensive CBTC Communications System that meets the Contract requirements:

    a. Data Cable Network (DCN) - The DCN shall consist of existing dark SFMTA fiber optic cable and network equipment that may be used by Contractor subject to SFMTA approval, and any new fiber optic cable and equipment, copper communications cable, and any network equipment as necessary to provide a path diverse Ethernet based transport system between and among CBTC System elements and SFMTA facilities.

    b. Wireless Equipment - The wireless equipment includes controllers, cabling, antennas, and transceivers as required to provide CBTC data communications between the wayside CBTC Systems, Control Centers (Primary and Backup) and all onboard rail Vehicle CBTC Systems per the CBTC design. The wireless system shall include all transceivers and ancillary equipment as required.

    c. Network Devices and Systems – All necessary network devices, including routers, switches, device servers, code systems and other devices, as required by Contractor's design. These devices shall have a comprehensive end-to-end Data Communications Subsystem for CBTC Equipment and all data interfacing of CBTC Equipment to other SFMTA subsystems as required by the Project specifications.

    d. Communication Interfaces – The physical, electrical, and logical interfacing support for all required interoperable protocols between and among all CBTC System elements and designated CBTC Communications System elements.

e. Network Security System (NSS) - Contractor shall include, as an integral component of their design, appropriate network security devices, such as firewalls, Intrusion Detection Systems (IDS), centralized Authentication, Authorization, and Accounting (AAA) management for users who connect and use a network connection as approved by SFMTA.

f. CBTC Network Management System (NMS) - The CBTC NMS shall have remote Configuration, management, monitoring and control of all CBTC communications network elements.

g. Power Systems – The Wayside Communications Power Systems shall be dedicated solely to the CBTC Communications System.

h. Ancillary devices and network equipment as required for a complete communications network from end-to-end, including all LANs, WANs and other systems.

27. Contractor shall submit a DCS Interface Control Document (ICD) for SFMTA approval, that includes data flow diagrams that show the data flow between systems and devices. This ICD shall describe and document all physical, electrical, and other interfaces and protocols between:

    a. The DCS and all CBTC Subsystems,

    b. The DCS and all CBTC elements provided as part of Contractor's CBTC System,

    c. The DCS and SFMTA supplied communications Systems, and

    d. The DCS and SFMTA supplied communications facilities utilized by Contractor

28. The CBTC Communications System is a closed network, as specified by CENELEC EN50159 and shall not be connected to the Internet or any other network without the express, written approval of SFMTA, as specified in Section 6.

29. The CBTC NMS shall report all alarms and reports at both the primary and backup Control Centers as specified in Section 20.

30. The Wayside Communications Power Systems shall be isolated from any signal system power system, whether existing or new. Contractor is solely responsible for the design and provision of an SFMTA approved isolation methodology and devices for any Communications Power Systems or CBTC Communications System element that may electrically or mechanically interface with any signal systems, including, but not limited to, Vital signal Interlocking and crossing devices.

31. The Data Communications Subsystem shall include the following characteristics:

    a. Contractor shall design and provide the DCS with resiliency and redundancy and with no single point of failure.

    b. Contractor shall design and provide the DCS with Quality of Service (QoS) functions.

    c. Equipment failure in the DCS shall result in switchover to backup equipment with no impact to the CBTC System.

    d. All network connections shall consist of redundant and resilient links.

    e. Contractor shall design and provide the DCS meeting CBTC System requirements regarding latency, throughput, failover, and security.

    f. DCS communication bandwidth shall support the worst-case traffic loading of all nodes connected to the DCS.

g. DCS design shall have a minimum 50% spare bandwidth for future growth.

h. DCS components shall meet the requirements for obsolescence and maintainability outlined in Sections 13, 14 and 30.

32. Contractor shall submit for SFMTA approval at the Final Design the QoS Design Implementation [CDRL], including prioritization protocols/levels for all network traffic types.

a. The QoS functionality shall prevent overloading of the DCS due to normal and unexpected network traffic.

26.3 DATA CABLE NETWORK (DCN)

26.3.1 DCN: DESCRIPTION OF WORK

1. Contractor shall supply all labor, Materials, tools, Equipment, and incidentals necessary to design and implement the CBTC Data Cable Network (DCN), with the exception of work performed by Installers, in accordance with the requirements specified in this Contract.

2. Contractor shall design the DCN fiber optic network using existing SFMTA existing fiber optic resources (i.e., "Dark Fiber").

a. Where fiber is needed and not available, Contractor shall design desired links (including a minimum of 50% spare unused fiber) for installation by SFMTA.

b. The design shall only specify fiber optic quantities and a point-to-point diagram showing fiber termination locations. SFMTA will perform the design of physical routing for the new cable (e.g. existing and new duct bank use, surface conduit, hangers) all the way to a demarcation Patch Panel (PP) or Fiber Distribution Panel (FDP).

3. Contractor shall supply, configure, test and commission all DCN network devices as required for a fully functioning CBTC/DCS System.

a. This scope shall include all CBTC/DCS Equipment beyond existing SFMTA assets that may be provided (e.g. dark fiber, FDPs, rack space) as described above.

4. Contractor shall test and verify the performance of all dark fiber optic strands that are provided by SFMTA to Contractor to be used as part of the DCN prior to connecting the fibers to any CBTC Equipment.

5. Contractor shall supply all permits and bear all associated costs pertaining to the implementation, installation and testing of Contractor's DCS, except those permits listed in Section 9 as SFMTA Furnished Items.

6. Contractor shall supply all engineering labor, tools, and Materials required to implement and fully test a fully operational CBTC DCN in accordance with these Contract Specifications.

7. Contractor shall submit documentation of as-built conditions and acceptance and operational tests.

8. Any law or regulation of the State of California or other local regulating body having jurisdiction over this Equipment shall apply.

26.3.2 DCN: TESTING

1. Through testing and inspection, Contractor shall verify and validate that the DCN meets all the requirements in these Contract Specifications.

2. Contractor shall test and inspect all items of Hardware and Software as described in Section 31 and elsewhere in these Contract Specifications.

3. Contractor shall design and implement a DCN test plan, as part of the overall Test Plan described in Section 31, to perform an Optical Loss Test (OLT) on all strands of existing dark fiber used by Contractor and all strands of Contractor-designed, SFMTA-furnished, and installed fiber optic cable, including all terminations.

4. Within 7 days after testing, Contractor shall submit full test documentation to SFMTA for approval prior to installation.

5. Contractor shall perform an OLT on all utilized strands of each fiber span required for a fully functioning CBTC System, including all intervening existing SFMTA cables and jumpers.

    a. If any deficiencies uncovered during this testing are determined to be related specifically to cables furnished and installed by Contractor, Contractor shall correct such deficiencies to the full satisfaction of SFMTA at no additional cost to SFMTA.

    b. Contractor shall report immediately to SFMTA any deficiencies discovered during testing that are determined to be related to existing SFMTA cable plant, and SFMTA will correct such deficiencies at no additional cost to Contractor.

6. Contractor shall verify all fiber optic test equipment is calibrated in accordance with the test equipment manufacturer's recommendations at the time of testing the fiber.

7. Contractor shall confirm that all fiber optic test equipment is in good working condition.

8. Before any measurements are made, Contractor shall perform all cleaning as recommended by the test equipment manufacturer.

    a. This shall include but not be limited to cleaning bare fiber ends, fiber connector ends and optical jumpers thoroughly with alcohol using lint-free wipers and blown dry with compressed, clean air.

26.4 CBTC WIRELESS NETWORK (WN)

26.4.1 WN: DESCRIPTION OF WORK

1. Contractor shall supply all engineering labor, Materials, tools, Equipment, Software, and incidentals necessary to implement the CBTC Wireless Network system, in accordance with the Contract Documents.

2. Contractor shall design and Furnish a wireless system with 100% wireless coverage on SFMTA right-of-way.

3. Contractor shall design the CBTC Wireless Network such that no single point of failure can disable normal CBTC functionality between a Vehicle and the wayside or the Central Equipment. Note that this will require two wireless paths (or more) using different technologies/providers to each Vehicle.

4. If Contractor proposes a leased, private network solution, Contractor shall assist in procuring this solution on SFMTA's behalf.

5. Contractor shall supply any permits and associated costs required to fully implement the CBTC Wireless Network.

6. Contractor shall comply with FCC Section 106 Requirements which involves filing Tower Construction Notification (TCN), E-106 and responding to inquiries from Tribal Organizations and local State Historic Preservation Officer (SHPO) that may have interest in a proposed antenna location.

7. Contractor shall adhere to all FCC rules and regulations pertaining to radio operations in these frequency bands.

8. Contractor shall supply all engineering labor, tools, and Materials required to implement and test a fully operational CBTC Wireless Network systems in accordance with these Contract Documents.

9. Contractor shall submit documentation of as-built conditions and acceptance and operational tests.

10. Contractor shall provide plans and procedures for use by the Installer for antenna and radio installation on SFMTA's catenary structure.

11. Contractor shall ensure that these radios and antennas are installed where feasible and required, with antenna height not exceeding 35 feet Above Ground Level (AGL).

12. Contractor shall specify in its design only unistrut products for any antenna and radio attachment onto the catenary structure. Drilling of catenary structure is prohibited.

13. Contractor shall submit to SFMTA any exceptions to this installation requirement for review and approval as part of FDR.

14. Contractor shall conduct a structural analysis to determine the structural integrity of catenary structures before any radio equipment is installed.

15. Contractor shall submit a copy of each Structural Analysis Report [CDRL] to SFMTA for review.

16. Contractor shall design all coaxial cables between the antenna and the radio in Rigid Galvanized Steel (RGS) or Schedule 80 PVC conduit to prevent vandalism.

17. The RGS shall cover a minimum of 10 feet from ground level and 5 feet from the antenna.

18. RGS shall bond to the catenary structure steel in accordance with SFMTA bonding Standards.

19. Contractor shall perform any and all necessary site surveys, communications environment studies, analysis, and tests required to support the design, installation, testing, and Commissioning of the Radio Subsystem of the CBTC Communications System. This includes frequency analysis and understanding of the frequencies already in use in the Project area to understand any interference.

20. The Wireless Network System shall perform in accordance with TIA-TSB-88.2-F 2021 (or latest revision).

21. Wireless equipment shall have the same resiliency and redundancy level as the DCS wired or cabled connections, with no single point of failure.

22. Wireless connections shall continue to operate transparently to the CBTC System in heavy street traffic condition with on street Vehicles transmitting on radio frequencies for data connectivity, and obstacle avoidance.

23. Contractor shall perform tests of the installed CBTC Wireless Network System to demonstrate that the System meets the requirements in the Contract Specifications.

24. Contractor shall mitigate any identified System deficiencies at no additional cost to SFMTA.

25. Contractor shall supply all engineering designs, installation plans and procedures for installation by SFMTA Installers.

26. Contractor shall develop designs in accordance with the Contract Specifications and all applicable Standards, and Codes.

27. Contractor shall test the Data Communications subsystem in accordance with applicable requirements of Section 31 and the latest version of TIA-TSB-88.3-E.

26.4.2 WN: CBTC WIRELESS HARDWARE

26.4.2.1 WN: CBTC WIRELESS TRANSCEIVERS

1. There are two types of Data Radio Transceivers required for this Project:
    a. Wayside Transceivers
    b. Mobile Transceivers (onboard Vehicles)
2. All Transceiver requirements that are not specifically identified as a Wayside Transceiver requirement or a Mobile Transceiver requirement shall apply to both Wayside and Mobile Transceivers.
3. The Mobile Transceiver requirement shall apply regardless of the Vehicle's movement or speed.
4. The Data Wireless Transceiver shall meet the requirements of all applicable Codes; Contractor is specifically directed to meet the requirements of Code Federal Regulations Title 47, Communications.
5. Contractor shall supply a CBTC wireless communications subsystem which includes:
    a. Communications Hardware, Software, cabling, and other devices as required to provide a functional interface to the DCS and
        i. CBTC onboard Equipment
        ii. Wayside Signaling Equipment,
        iii. Network Management System,
        iv. Network Security System,
        v. SFMTA Fiber Optic Network
        vi. any other subsystem associated with other radio systems supplied by Contractor, and
        vii. SFMTA Communications Infrastructure.

b. Data transceivers or other wireless data communications devices to be installed on the wayside, on Vehicles, in yards, and in storage facilities.

c. Built-in interfaces with the Network Management System to provide alerts, alarms, and advance warning to maintenance personnel about potential problems with the Wireless Network System. This shall include, but not be limited, warnings for insufficient Signal to Noise ratio, high VSWR, high temperature, high bit error rate, high packet loss, and failure to associate and/or establish connection with an LRV.

d. All mounting Hardware, brackets, cases, racks, or other items required for the Wireless Network System installation.

e. Ubiquitous RF coverage on all mainline tracks, storage tracks, sidings, and yards. Contractor shall design the RF Network such that a single failure will not cause a Service Affecting Failure.

f. Equipment to support operations of SFMTA System anywhere within SFMTA property. The CBTC Wireless Communications Subsystem shall include Equipment that can be installed in close confines of SFMTA owned limited right-of-way property.

g. An RF network with sufficient filters and protections to overcome noise floor fluctuation and deep fades that may occur as a result of RF signal blockage, for example, by a truck or other automobile parked between the wayside antenna and the LRV

h. A design for installation on retrofit Vehicles.

i. Overall CBTC required performance for wayside-to-Vehicle and Vehicle-to-wayside communications.

j. A standard protocol structure that is consistent with open architecture principles and provides for growth in function, message, number of units addressed, and types of devices addressed.

k. An addressing scheme that supports safety, flexibility, and message delivery Reliability requirements.

6. To be suitable for handling CBTC data, the RF data communications subsystem shall include a protocol structure for the CBTC Wireless Network System that ensures timely and secure delivery of critical train control messages.

7. The DCS shall have protection against unauthorized access to the network, spoofing, hacking, or sabotage from persons and computers outside of SFMTA System.

8. The CBTC RF Data Communications Subsystem protocol shall:

a. Utilize the latest IEEE 802.11i Standard such as WPA2/3 (Wi-Fi Protected Access) for link encryption for all over-the-air messaging. The encryption shall apply to the wireless portion of any point-to-point communication link in the DCS as a minimum, with the applicable routers using the more secure WPA3 security protocol, or, with the routers being upgradeable from the current WPA2 to WPA3 security level.

b. Include Forward Error Correction (FEC) or other techniques to support the specified data throughput and latency requirements.

c. Include Layer 5 Session Binding or equivalent method of ensuring that commands are only accepted from authorized and validated sources.

d. Not use any proprietary protocols or Standards without prior approval from SFMTA.

9. The CBTC radio subsystem shall have a modular design that supports replacement of the data radio without significant impact on other aspects of the System design or operation.

10. After installation, Contractor shall verify the proposed RF coverage, data throughput and C/I+N design meets SFMTA approved design and the requirements of this specification.

11. Contractor shall submit an RF coverage report [CDRL] that details the findings and test results to SFMTA for review and approval.

12. The Radio shall:

    a. Support wireless mesh capability on multiple radios and on multiple frequency bands in a highly mobile environment.

    b. Interface to the Data Cable Network (DCN) provided by Contractor.

    c. Not implement a master controller or root node design architecture.

    d. Implement a make-before-break method for switching between radio channels.

    e. Provide at least one of the following modulation techniques.

        i. Frequency Hopping Spread Spectrum (FHSS)

        ii. Dynamic Sequence Spread Spectrum (DSSS)

        iii. Orthogonal Frequency Division Multiplexing (OFDM)

    f. Provide error reporting, for example: radio is unable to connect, or associate with a node, high data collision, excessive packet loss and high VSWR or reflected power.

13. The RF Data Communications subsystem shall use frequencies as allowed by FCC and approved by SFMTA.

14. The Radio interface protocol shall report appropriate error Codes. For example: radio is unable to connect, or associate with a node, high data collision, excessive packet loss and high VSWR or reflected power.

26.4.3 WN: CBTC RADIO EXECUTION

26.4.3.1 INSTALLATION DOCUMENTATION

1. Contractor shall supply installation and test documentation necessary for the Wayside Equipment Installer to install the wireless equipment according to Contractor's design and at locations chosen by Contractor.

26.4.3.2 TRANSMISSION LINE CABLES

1. Contractor's design shall comply with the following in its installation and test documentation used for the installation and testing of Transmission Line Cables:

    a. Transmission line installations shall comply with manufacturer recommendations with regard to grounding, vertical and horizontal run weight support, and connectors, except as noted in the Contract Documents.

b. The transmission line manufacturer shall verify that the selected transmission line connector is compatible with its transmission line.

c. If a radio house is used, the Installer will install the transmission line through a matching port-cushion that has been installed in the transmission line entry panels.

d. The transmission line shall immediately terminate inside the house and interconnect with the lightning surge arrestor using a transmission line jumper cable.

e. Contractor shall design a blank port-cushion in any unused waveguide entry panels.

f. At radio houses, Contractor shall Furnish a lightning arrestor ground bar, lightning arrestor, and 20 feet of size 6 AWG THWN-2 green insulated ground wire with compression lugs (only one lug installed) for interconnecting the lightning arrestor ground bar to the main ground bar in the node house.

2. Contractor's design shall require weatherproofing all Transmission Line Connectors from the polyphaser to the antenna with appropriate weatherproofing tape.

3. Contractor's design shall include construction design of Transmission Line Jumpers to interconnect antennas, antenna transmission lines, and radio equipment.

4. Contractor's design shall include connection design of Base Antennas to Base Transmission Line using low-loss jumper cable.

5. Contractor's design shall require Installer to install external jumper cable with drip/stress loop.

6. Contractor shall supply Materials and installation design requirements for Lightning Arrestors on each antenna system within a site as follows:

   a. For radio houses, Contractor's design shall require mounting each arrestor on one of the two copper ground plates near the transmission line waveguide entry panel.

   b. Contractor's installation instructions shall require the grounding all Transmission Line Cables using appropriate Grounding Kits.

7. Contractor's design shall require the Installer to secure ground wire to antenna poles using Ground Wire Clips, a minimum of one clip per every three feet along the pole.

26.5 NETWORK MANAGEMENT SYSTEM (NMS)

1. Contractor shall supply a functional NMS as specified in Section 20.3 (Network Management System).

26.6 NETWORK SECURITY SYSTEM (NSS)

1. Contractor shall supply a functional NSS as specified in Section 6.5 (Network Security System).

26.7 VOICE COMMUNICATIONS SYSTEM

1. Contractor shall use the existing voice radio system (See Section 9, SFMTA Furnished Items).

2. If the existing voice radio system does not meet System requirements or requirements in these Contract Specifications, then Contractor shall design and implement any necessary changes.

26.8 UTILIZATION OF SFMTA INFRASTRUCTURE

1. Contractor shall submit a design which utilizes existing SFMTA infrastructure to the maximum extent possible.

2. Contractor shall determine whether existing equipment is suitable for inclusion in the CBTC System.

3. Within the first 45 days of the Project, Contractor shall review the available existing SFMTA IT infrastructure and equipment with the SFMTA.

4. As part of the CDR submittal, Contractor shall submit a Re-use of SFMTA Communications Infrastructure Document [CDRL] outlining existing SFMTA resources to be used.

26.9 COMMUNICATIONS CDRL DELIVERY

1. As part of the Preliminary Design Review package, Contractor shall submit:
    a. DCS Design Document [CDRL].
    b. DCS Interface Control Document [CDRL]
    c. DCS Test Plan [CDRL]

2. As part of the Final Design Review package, Contractor shall submit:
    a. DCS Test Procedures. [CDRL]
    b. IP Addressing Scheme [CDRL]
    c. DCS device naming and labeling scheme. [CDRL]
    d. Equipment Data sheets [CDRL]:
        i. Manufacturer data sheets for all proposed DCN equipment and Software, ethernet cables and fiber-optic cables
        ii. Manufacturer data sheets, certified test data and plots for antenna patterns in both the horizontal and vertical planes.
        iii. Manufacturer data sheets and assembly procedures for each type of cable connector.
        iv. Manufacturer certification that each specific type of cable is compatible with its associated connector.
        v. Manufacturer data sheets for each type of connector adapter.
        vi. Manufacturer data sheets for weather and water proofing products.
        vii. Manufacturer certified test data for each spool of transmission line.
        viii. Manufacturer data sheet and manuals for the proposed base and mobile radio.
        ix. Catalog data sheets and operations manuals for all Equipment in this Section.
        x. Manufacturer data sheet of proposed polyphaser.
        xi. Contractor shall import all Equipment Data Sheets into SFMTA EAMS.
    e. Propagation maps of the proposed radio coverage. [CDRL]
    f. Carrier-to-interference (C/I+N) maps. [CDRL]

g. Link budget. [CDRL]

h. Intermodulation study that shall include all wireless system and radio systems currently operated by SFMTA on SFMTA right-of-way and the proposed radio system for CBTC RF communications. [CDRL]

i. Electromagnetic Interference (EMI) study report and Radio Frequency Interference (RFI) study report indicating that the LRVs would not produce any EMI or RFI that would negatively affect the RF Data Communications system. [CDRL]

j. A database containing all site radio equipment located at every individual field point along the alignment including, but not limited to, antenna type, antenna height, antenna manufacturer, antenna azimuth where applicable, coaxial cable type and length, transceiver manufacturer, transceiver output power, channel frequency, channel bandwidth, Effective Radiated Power (ERP) and fiber optic node to which the transceiver site is connected to.[CDRL]

k. A document describing the capacity of the radio communications link and an estimate of the expected peak load. [CDRL]

l. A report describing the characteristics of the RF data link protocol that demonstrates it will meet all requirements specified herein. [CDRL]

m. Installation plan, material acceptance requirements, Drawings and test procedures for all radio communication related equipment. [CDRL]

n. If the Radio is compliant to any applicable rule or regulations by waiver, Contractor shall submit documentation of the waiver with, or prior to, submittal of product data for the Radio Transceiver. [CDRL]

o. A proposed design including Bill of Materials of the antenna attachment for both catenary structure and other poles for approval by SFMTA Project Manager. [CDRL]

p. A radio frequency reuse plan for the entire SFMTA right-of-way radio system for all frequencies used. [CDRL]

3. As part of field testing activities, Contractor shall submit:

a. Drive test data along with a drive rest report that shows Contractor's proposed RF communications system meets the RF coverage requirements. [CDRL]

b. The calibration certificate of all Equipment that will be used for RF testing, [CDRL]

c. A Radio Link Throughput Test Report showing that the RF link would provide sufficient capacity to meet the CBTC over-the-air communications need plus 50 percent additional capacity. [CDRL]

d. Data from Contractor sweeps of the transmission lines and antennas at the frequencies in which the CBTC Wireless Network System will operate to determine if the system meets the manufacturer specification and the requirements stated herein.

i. The sweeps shall include return loss or VSWR and insertion loss.

ii. After installation, Contractor shall perform return loss, insertion loss and distance-to-fault sweep of the entire transmission system.

iii. Contractor shall submit both sets of sweep data for review by SFMTA. [CDRL]

e. Photographs showing all connectors weatherproofing installation. [CDRL]

f. Photographs showing all lightning protection system grounding points. [CDRL]

Table 26-26: Communications CDRL Table

CDRL #	CDRL Title
26.01	Data Communication System (DCS) Design Document
26.02	DCS Interface Control Document (ICD)
26.03	Structural Analysis Report
26.04	RF Coverage Report
26.05	Re-use of SFMTA Communications Infrastructure Document
26.06	DCS Test Plan
26.07	DCS Test Procedures
26.08	IP Addressing Scheme
26.09	DCS device naming and labeling scheme
26.10	Equipment Data Sheets
26.11	Propagation Maps of the Proposed Radio Coverage
26.12	Carrier-to-Interference (C/I + N) Maps
26.13	Link Budget
26.14	Intermodulation Study for SFMTA Radio
26.15	Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) Study Reports for LRVs
26.16	Radio Site Characteristic Database
26.17	Document Describing the Capacity of the Radio Communications Link and An Estimate of Expected Peak Load
26.18	Report Describing the Characteristics of the RF Data Link Protocol
26.19	Installation Plan for All Radio Communications Related Equipment
26.20	Waiver for Product Data for the Radio Transceiver (if required)
26.21	Proposed Design and Bill of Materials of Antenna Attachment to Catenary Structures
26.22	Radio Frequency Re-Use Plan
26.23	DCS Test Data and DCS Test Report
26.24	Calibration Report for Test Equipment
26.25	Report Verifying Proposed Coverage, Data Throughput and C/I +N Design has been achieved
26.26	Radio Link Throughput Report
26.27	Antenna and Transmission Line Sweep Test Report
26.28	Connectors Weatherproofing Installation Photographs
26.29	Lighting Protection System Grounding Points Photographs
26.30	Quality of Service (QoS) Implementation

27 EQUIPMENT REQUIREMENTS

27.1 PURPOSE

1. The Section specifies general requirements applicable to all Equipment and specific requirements that are applicable to subsystems or components of the CBTC System.

27.2 GENERAL

1. Contractor shall supply all Equipment to deploy a complete CBTC System that meets the Contract requirements and the approved System design.

2. Contractor shall conduct an ergonomics assessment for all CBTC workstations and include the results in its workstation design.

3. Contractor shall submit a Workstations Human Factor Analysis [CDRL] as part of the System Design Documents.

4. Contractor shall design and provide all CBTC Equipment components to the maximum extent practicable using Commercial Off The Shelf (COTS) products and Software.

5. All CBTC Equipment shall consist of a modular design that supports replacement of the Equipment or incremental upgrades without impact on other aspects of the System design or operation.

6. Contractor shall co-locate the placement of CBTC Equipment as much as possible to minimize the space required and to provide for ease of maintenance

7. Contractor shall protect all installed solid-state equipment, as a package, from lightning discharges, electrostatic discharge, power line surges, and electromagnetic interference in a manner approved by SFMTA.

8. Contractor shall Furnish and install approved types of surge suppressors and lightning arrestors.

9. Contractor shall supply solid-state devices that are heavy duty, industrial or commercial types and commercially available from at least two manufacturers.

10. All printed circuit boards that connect by means of connectors shall have keyed connectors to prevent them from being incorrectly inserted in the sockets.

11. All printed circuit boards shall have conformal coatings to protect against dust and humidity.

12. All Equipment shall continue to function during, and not be damaged by, switching of primary power by the automatic transfer panels.

13. Contractor shall not design “Daisy-chain” connections (i.e. sequential connections) of wayside Equipment. Only point to point and ring type connections are permitted for wayside Equipment.

27.3 CBTC EQUIPMENT ENVIRONMENTAL REQUIREMENTS

27.3.1 ENVIRONMENT REQUIREMENTS

1. The CBTC System shall operate in all SFMTA owned and operated environments. A severe environment is one to which no controls or conditionings are applied. A benign environment is one in which the ambient conditions are closely controlled at a predetermined level. In order to adequately

specify the appropriate operating range for each piece of Equipment used, the environments have been subdivided into the following eight categories:

a. Class A: Roadbed - All Equipment directly attached to track components such as rails, ties, or mounted between the ties, in striking distance of debris falling from or attached to a Vehicle (e.g., transponder tags, switch machines, Trip stops). Much of SFMTA's rail is enclosed or otherwise hardened so as to withstand heavy rubber tire vehicles driving over it;

b. Class B: Wayside Outdoors - All Equipment located within 20 ft of track centerline, but not directly on the track bed (e.g., wayside signals, radio antenna & masts, radio cases, Junction boxes);

c. Class C: Wayside Signal Enclosures - All Equipment installed in relay rooms, bungalows and Equipment cases which provide basic shelter from rain and snow. No heating, air conditioning, and humidity control is provided (e.g., Zone Controllers, microprocessors, radio equipment, transformers, relays, batteries.);

d. Class D: Wayside Data Communications Equipment - All data communications equipment installed in relay rooms and bungalows which provide basic shelter from rain and snow. Heating and some air conditioning are provided for data communications equipment only. Contractor shall supply HVAC equipment with backup if the CBTC Equipment cannot function in this environment.

e. Class E: Computer Rooms - All Equipment located in benign environment in Control Center and Tower Rooms (i.e., CBTC computers, monitors, displays, printers, and workstations). Contractor shall supply environmental conditioning equipment with backup if the CBTC Equipment cannot function in this environment.

f. Vehicle Interior - All Equipment mounted in the enclosed interior spaces of the Vehicle. This category of environmental conditions is specified as E4 and E5 in IEEE Standard 1478.

g. Vehicle Exterior, Body Mounted - All Equipment mounted on space outside the enclosed areas of the Vehicle, which is exclusive of direct contact with the rails ("sprung") (i.e., radio antennas). This category of environmental conditions is specified as E3 in IEEE Std 1478.

h. Vehicle Exterior, Truck Mounted - All Equipment mounted on "unsprung" components of the Vehicle (i.e., trucks, wheels, and axles). This category of environmental conditions is specified as E1 and E2 in IEEE Std 1478.

4. All wayside Equipment shall meet AREMA Communications and Signals, Part 11.5.1.

5. All onboard Equipment shall meet IEEE 1478 IEEE Standard for Environmental Conditions for Transit Railcar Electronic Equipment.

27.3.2 SEISMIC REQUIREMENTS

1. Contractor shall provide installation designs, so all CBTC Equipment is certified for a Zone 4 seismic rating as specified in the Telcordia GR-63 CORE Seismic Standard.

2. Contractor shall supply industrial model equipment housed in Zone 4 seismically rated cabinets.

3. Contractor shall design and provide to SFMTA (for installation by the Installer), all seismic bracing, and seismic anchoring to support compliance with the Telcordia GR-63 CORE Seismic Standard.

4. Contractor's Safety Assurance Deliverables shall verify and validate that risk mitigation requirements have been implemented protecting all locations, Equipment, personnel and patrons subject to potential seismic risks. See Section 6 (System Safety and Security Management).

27.4 POWER AND GROUNDING REQUIREMENTS

1. Contractor shall design all CBTC Equipment such that:
    a. Equipment, personnel and public are protected against electrical Hazards (i.e., shock, electrocution), including lightning.
    b. The impact of Electromagnetic Interference (EMI) and electrostatic interference is reduced.
    c. Potentials to grounding equipment neutrals is reduced.
    d. A single point grounding system and associated ground rods, as applicable, for equipment enclosures, cabinets, drawers, assemblies, and sub-assemblies, and comply with IEEE Std. 80 Guide for Safety in AC Substation Grounding step and touch potential limits is provided
    e. AC or DC power lines are protected from surges or transients.
    f. Wires and cables in Control Centers, Technical Rooms, Tunnels, are LSHF (Low Smoke, Halogen Free) as per NEC 2020, UL 2556, 2885
2. The CBTC System grounding and bonding shall meet:
    a. IEEE 142- IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
    b. IEEE 837 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding
    c. IEEE 1100 - IEEE Recommended Practice for Powering and Grounding Electronic Equipment
    d. All applicable regulatory requirements as specified in Section 7.

27.5 ENCLOSURE REQUIREMENTS

1. For Equipment mounted in locations with exposure to dust or moisture, the Equipment supplied shall comply with the following requirements:
    a. Equipment mounted on the exterior of the Vehicle shall have dust and moisture protection equal or greater than IP65 rating of the IEC 60529 Standard.
    b. Equipment mounted in location with weather exposure shall protect Equipment and Equipment functionality equal to or greater than IP65 rating of the IEC 60529 Standard.
    c. Equipment mounted in a location with risk of flooding shall have protection equal to or greater than IP68 of the IEC 60529 Standard.
    d. Connectors and cables utilized for exposure locations shall have sufficient protection to be equal or great then IP65 rating of the IEC 60529 Standard.

27.6 ELECTROMAGNETIC INTERFERENCE (EMI) / ELECTROMAGNETIC COMPATIBILITY (EMC)

27.6.1 EMC PROGRAM PLAN

1. Contractor shall submit an EMI/EMC Program Plan [CDRL] that meets the Control Plan requirements specified in APTA SS-E-010-98, Standard for the Development of an Electromagnetic Compatibility Plan and applicable Codes specified in Section 7.

2. The EMC Program Plan shall:

    a. Establish all EMC requirements and tolerances

    b. Describe EMC Program scope, tasks, techniques, Deliverables, and Milestones

    c. Describe the organization of Contractor and Subcontractor staff who will perform the EMC Program

    d. Specify roles, responsibilities, activities, and Deliverables of Subcontractors. Contractor shall verify that Subcontractors follow the EMC Program Plan or provide a compatible Subcontractor EMC Program Plan

    e. Describe monitoring and evaluation of Subcontractor EMC activities and Deliverables

    f. Describe interfaces to and coordination with other CBTC System Assurance activities

    g. List each EMC Program Deliverable, and for each Deliverable, state the participants, the approach to develop the Deliverable, the inputs and outputs of the Deliverable, and the Deliverable contents

    h. Present Contractor's methodology to ensure compliance with EMC requirements

    i. Establish the EMC Qualification Test Program Plan covering all EMC qualification tests, for verification of compliance with EMC requirements

27.6.2 EMI/RFI SURVEY

1. Contractor shall submit an EMI/RFI (Electromagnetic Interference/Radio Frequency Interference) Survey Plan [CDRL].

2. Contractor shall perform the EMI/RFI Survey per the accepted EMI/RFI Survey Plan.

3. The EMI/RFI Survey Plan shall describe the measurement arrangements and procedures, identify Vehicles and locations where and when measurements will be made, and identify possible EMC issues.

4. The EMI/RFI Survey shall consist of the following actions:

    a. Survey the Right-of-Way (ROW) for potential sensitive neighbor facilities, including research facilities, universities, hospitals, and industrial facilities with sensitive equipment, areas of notable concern. Contractor shall observe ROW Surveys at varied times of day (peak, off-peak, and non-revenue hours).

    b. Survey the ROW for potential EMI/RFI emitters that could interfere with sensitive CBTC electronic Equipment.

c. Survey Vehicle fleets in applicable conditions such as standing, in storage, at constant speed, during acceleration and deceleration, outdoors, in the subway, or while traversing a power section gap to determine the existing EMI/RFI environment and use the results to verify CBTC Equipment does not adversely affect, and is not adversely affected by, Vehicle Equipment.

d. Survey conditions in rooms which will contain CBTC Equipment, to determine the existing EMI/RFI environment, and use the results to verify CBTC Equipment does not adversely affect, and is not adversely affected by, other Equipment.

e. For sites and Vehicles identified in this specification, measure ambient electric field levels from 10 kHz to 6 GHz and ambient magnetic field levels from DC to 800 Hz. Measurement locations and times shall include peak, off-peak, and non-operating periods.

f. Survey radio frequencies in use at and near ROW, including unlicensed bands and public safety agencies.

5. At the conclusion of the EMI/RFI Survey, Contractor shall submit an EMI/RFI Survey Report [CDRL].

6. The EMI/RFI Survey Report shall:

a. Provide complete information on locations and Vehicles measured, results, and findings and conclusions regarding possible EMC issues

b. Identify potential sensitive neighbor facilities and propose EMI/RFI mitigation measures as necessary

c. Identify potential emitter neighbor facilities and propose EMI/RFI mitigation measures as necessary

d. Identify Vehicle susceptibility and emission impacts and propose EMI/RFI mitigation measures as necessary

e. Provide compatible immunity and emission limits for CBTC Equipment

27.7 CBTC CENTRAL EQUIPMENT REQUIREMENTS

1. Contractor shall submit a design where the CBTC Control Center Equipment is installed in the primary Control Center at the Transportation Management Center (TMC) on Market Street and in the backup Control Center located at the West Portal OCC.

2. Contractor shall Equip both Primary and backup Control Centers with identical complete sets of Hardware, operating systems, and Software.

3. Contractor shall design the backup Control Center to be operated as a cold stand-by disaster recovery system.

4. Contractor shall design, submit and supply Equipment and Software so the backup Control Center can function as a Training Center for SFMTA personnel during normal operation.

5. In case of emergency, the CBTC System shall allow manual switchover from the Primary to the backup Control Center without any modification of the physical network connections.

6. For the Automatic Train Supervision (ATS), Maintenance and Data Communications equipment, Contractor shall provide the latest generation of COTS equipment.

7. Contractor shall standardize any Hardware, firmware and Software provided for any Equipment that performs the same function.

8. In absence of safety requirements or other specific constraints, Contractor shall design the CBTC subsystems to allow virtualization of the servers in SFMTA Data Warehouse.

9. The design of the new Control Center Equipment shall consider human factors and comfort in conformity with standard data center techniques.

10. The CBTC Control Center Equipment shall include:

    a. Central servers

    b. Cabinets, cabling, and power supplies as necessary

    c. Equipment for data communications between the CBTC Control Center Equipment and CBTC wayside Equipment

    d. Transportation Controller workstations

    e. Maintenance and Diagnostics workstations

    f. Network Management workstations

    g. Simulation and test workstations

    h. All Equipment required to support interfaces between the CBTC System and SFMTA existing systems as specified in Section 28 (Interface Management Requirements)

    i. All other Equipment and provisions required to meet all CBTC functions specified in this Specification.

11. Contractor may use centralized architecture or virtualization so that the Contractor delivers the same functionality using fewer pieces of Equipment than is specified in this Section. This is acceptable as long as all functions assigned to the physical Equipment are met using the centralized architecture such that there is no change in functionality from what has been specified.

12. Any Equipment added to the TMC and Equipment interface updates performed by Contractor shall have no impact to the operation of the other non signalling functions of the TMC.

13. Contractor shall use the current plans and as-built Drawings of both SFMTA Control Centers provided by SFMTA as a baseline to design and propose locations of all CBTC Equipment to be installed at both the TMC and the West Portal OCC.

14. Contractor shall survey and update SFMTA provided as-built Drawings to include the new CBTC Equipment.

15. Contractor shall submit a primary Control Center floor plan [CDRL] and Backup Control Center floor plan [CDRL] at PDR for SFMTA approval,

16. The primary Control Center floor plan and Backup Control Center floor plan shall include workstations, server rooms and all other necessary provisions.

17. The CBTC Equipment design shall integrate with the Control Centers Mechanical and Electrical Interfaces.

18. Design of Central servers, databases, data flows, and workstations shall comply with SFMTA Requirements for Technology Projects provided in Appendix J to the Agreement.

19. Contractor shall evaluate the heating, cooling and lighting conditions of each room in the Control Centers where Equipment will be located.

20. In the event the cooling, heating or lighting is evaluated as insufficient, Contractor shall notify SFMTA and include a list of proposed facility upgrades as part of the Preliminary Design Review.

27.7.1 VIDEO WALL

1. The control room at the TMC contains a video wall for display of transit system status.

2. The new CBTC ATS subsystem shall interface to the existing videowall as specified in Section 28.

3. Contractor shall supply a new video wall for the backup Control Center room, with the same functional characteristics and same interface as the existing TMC's video wall.

27.7.2 DATA CENTERS

1. Contractor shall design and Furnish two data center layouts [CDRL], one corresponding to the TMC Data Center and the other corresponding to the UMS Data Center, in the spaces allocated by SFMTA for the Contractor's use.

2. The data centers shall house the CBTC Central Equipment and all other necessary Equipment to meet the Contract requirements.

3. Contractor shall submit data center layouts as part of the Preliminary Design Review for SFMTA approval.

27.7.3 WORKSTATIONS

1. Contractor shall supply, for each Control Center:

    a. Five (5) Transportation Controller Workstations

    b. One (1) Maintenance and Diagnostic Workstation

    c. One (1) Network Management Workstation

    d. Three (3) Emergency Stop Buttons as specified in Section 17.7.1 (Emergency Stop Buttons)

2. In addition, Contractor shall supply:

    a. One (1) additional Transportation Controller remote Workstation for the Transportation Office located at 1 S. Van Ness 8th Floor.

    b. Three (3) Emergency Stop Buttons as specified in Section 17.7.1 (Emergency Stop Buttons) for the Transportation Office located at 1 S. Van Ness 8th Floor, if the SFMTA exercises this Option 5.

    c. Four (4) additional remote Maintenance Workstations to be located at 700 Pennsylvania, MME, and Green shops, and another location to be specified during the System Design Phase.

d. One (1) additional remote Network Management Workstation for a location to be specified during the System Design Phase.

3. The remote Workstations shall be redeployable to other SFMTA facilities without Contractor assistance so that SFMTA can relocate them at will.

4. Fiber Optic Network physical connections between both Control Centers and the remote workstations are not in the scope of this Contract.

5. Contractor shall design and supply each workstation as identical and equipped with six (6) 24" Full HD Monitors, one keyboard, and one mouse.

6. The Contract shall supply two (2) color laser printers, one located in TMC and one located in OCC, networked to the System to support print functions.

7. Contractor shall supply the Transportation Controller Workstations at the backup Control Center to be Configurable as four trainee workstations and one trainer workstation with the trainee workstations Configurable by job type.

8. Contractor shall submit the layout of the Control Center workstations [CDRL] as part the Preliminary Design Review package for SFMTA approval.

27.8 CBTC WAYSIDE EQUIPMENT REQUIREMENTS

1. The CBTC wayside Equipment shall include:

   a. Zone Controllers (ZC) or equivalent

   b. Interlocking Object Controllers

   c. Cut-over Cubicle (CoC)

   d. DCS Equipment

   e. Trackside Equipment

   f. All other necessary Equipment required for the fully functioning CBTC System

2. Contractor shall survey existing signal equipment rooms for suitability to house Contractor's CBTC Equipment, and either confirm that the room is suitable as-is, or submit designs to upgrade, modify, or retrofit the room, including electrical and mechanical infrastructure as needed to meet the environmental or other operating requirements of the Equipment.

   a. SFMTA will contract with a qualified Installer to perform necessary construction work.

   b. Contractor shall inspect Installer's work during construction and upon completion of that work to confirm the work is correct and complete.

   c. Contractor shall supply any furnishings, enclosures, racks, mounts or cabinets required for its Equipment.

   d. If modifications to a signal equipment room are not feasible, Contractor shall propose alternatives to physical modifications which can still meet design requirements.

3. Contractor's designs for wayside Equipment installation shall maximize the reuse of existing Interlocking Equipment rooms and other wayside facilities.

4. Contractor may use centralized architecture or virtualization so that the Contractor delivers the same functionality using fewer pieces of Equipment than is specified in this Section, or locates Equipment defined in this Section as wayside Equipment in a data center as opposed to a cabinet or wayside equipment room. This is acceptable as long as all functions assigned to the physical Equipment are met using the centralized architecture such that there is no change in functionality from what has been specified.

5. Contractor shall submit the Wayside Signal Equipment Room Layout [CDRL] as part of the Preliminary Design Review package for SFMTA approval.

27.8.1 ZONE CONTROLLER (ZC)

1. Contractor shall supply Zone Controllers and all their interfaces to other subsystems of the CBTC System and all other necessary provisions to meet the Contract requirements.

27.8.2 INTERLOCKING

1. The Contractor shall supply its vital Equipment, integrated into the CBTC System, as a replacement to the existing solid state and relay-based Interlockings. The existing Interlockings request position and receive the status of the switches, set routes, and receive the status of signals and other trackside Equipment if present.

2. Existing Interlockings which control junctions that coincide with a traffic signal-controlled street intersection are integrated with the street traffic signals so that the rail permissive signal is coordinated with the traffic signal phase corresponding to that movement. The Contractor shall reproduce this non-vital integration as specified in Section 28.8 (Traffic Signal Controller) such that this functionality is maintained with the replacement Equipment specified in this Section.

3. The Contractor shall supply the additional Interlocking Equipment kits specified in the option (Option 4) as described in Section 16.2 (System Architecture), if SFMTA exercises the option.

27.8.3 CUT-OVER CUBICLE

1. Should it be necessary for Contractor's Migration or testing approach, Contractor shall use temporary Vital Cut-over Cubicle (CoC), which requires minimal testing, for dual fit to allow safe switching between existing System and CBTC System:

    a. Contractor shall test, commission and safety certify the CoC before use.

    b. The CoC once Commissioned shall have no impact on the operation and safety of the existing system or CBTC System.

    c. The CoC shall have bi-stable relays.

    d. The CoC shall have security features to allow control by the authorized personnel locally and remotely.

    e. The CoC shall have visible indication locally and remotely on its control position.

27.8.4 TRACKSIDE EQUIPMENT

1. Contractor shall minimize Equipment mounted along the track, adjacent to or between the running rails, and restrict to those items providing a direct interface with the track, Vehicles, or personnel.

2. Contractor shall submit designs where the Equipment mounted between the running rail:

    a. Is covered in such a way that is easy to remove for maintenance purposes.

    b. Withstands the vibration associated with being mounted on the wood tie / ballast locations.

3. Contractor shall design the Equipment installation such that:

    a. The Equipment does not obstruct walkways or other areas of safety, and does not foul the dynamic envelope.

    b. No other Equipment requires to be removed to gain access to the trackside Equipment and no track side Equipment requires to be removed to gain access to other Equipment.

    c. It is compatible with routine maintenance such as rail grinding without overly complex removal and reinstallation requirements.

27.8.4.1 SIGNALS

1. The CBTC System shall Vitally control all wayside rail signals in CBTC Territory.

2. SFMTA has signals located both in the subway area and on the surface which are in the process of being converted to LED technology. Signals are SFMTA Furnished Items and are designed in accordance with SFMTA Rail Rule Book provided in Appendix J to the Agreement. For more information on the signal systems refer to SFMTA Integration Management Plan in the Reference Documents. The CBTC System shall interface with the existing rail signals.

3. Alternatively, Contractor may propose to replace the existing signals with new signals or decommission existing signals, subject to SFMTA approval. If Contractor proposes to replace or decommission the existing signals, Contractor shall explain the benefits of doing so to SFMTA during the Design Phase.

4. Renewal of existing wiring is in the scope of this Project. Contractor shall propose a program of inventory, testing and replacement, if necessary, of any existing wiring whose condition or arrangement may affect Contractor's ability to meet Contract Performance Requirements.

5. If signals are modified or new signals are added, Contractor shall provide and all necessary designs, Equipment and Materials necessary to install them.

6. All Contractor-submitted signaling designs shall comply with SFMTA signal requirements.

7. Contractor shall design new signals visible from the platforms at the stations listed in Section 16.3.1.5, for the purpose of working with the Train Depart Local Control Consoles described in that section if no existing signals are visible from those platforms.

8. Subway area signals are controlled directly by the current ATCS. and Contractor shall design and implement a Safety Critical interface directly with the signal unless SFMTA specifies that these signals are to be decommissioned.

27.8.4.2 SWITCH MACHINES AND SWITCH POSITION DETECTION

1. Switches and switch machines are SFMTA Furnished Items. SFMTA has several types of switch machines including Alstom GM4000A, GRS 55E which are being replaced by GM4000A, Alstom 5F which may also be replaced by GM4000A before the CBTC System is deployed, Irwin T3 and Hanning & Kahl. The CBTC System shall interface with the existing switch machines.

2. Contractor may request that SFMTA replace any of the existing switch machines with new switch machines during the Design Phase. If Contractor proposes to replace the switch machines, Contractor shall explain the benefits of doing so to SFMTA during the Design Phase.

3. Contractor shall propose a program of inventory, testing and replacement, if necessary, of any existing wiring whose condition or arrangement may affect Contractor's ability to meet the Performance Requirements of the Contract.

4. Contractor shall include in its installation plans any existing wiring it determines needs to be refreshed, and the Installer will perform the replacement.

5. Subway switch machines are controlled by the existing ATCS. Contractor shall provide a direct interface between the CBTC System and the subway switch machines.

27.8.4.3 TRANSPONDERS

1. Contractor shall supply programmable transponders that do not require batteries for operation.

27.8.4.4 INTERLOCKING LOCAL CONTROL PANELS

1. Contractor shall supply Local Control Panels (LCP) as alternate means for staff on platforms to operate Interlockings locally, as specified in Section 16.3.1.4 (Interlocking Local Control Panel).

2. The Local Control Panel will be located outdoors. Contractor may provide electromechanical or electronic Equipment for such local control functions. The Local Control Panel shall be rated for exposure to water and outdoor environmental conditions.

3. Contractor shall supply Local Control Panels in the specific locations as indicated in Section 16.3.1.4 (Interlocking Local Control Panel).

4. Contractor shall design anti-vandalism enclosures to protect the Equipment from unauthorized access as specified in Section 6.4.2 (Physical Security).

5. Contractor shall design and provide power supplies, data communications and all other necessary Equipment to install and connect Local Control Panels with the CBTC System.

27.8.4.5 TRAIN DEPART LOCAL CONTROL CONSOLE

1. Contractor shall supply Train Depart Local Control Consoles as specified in Section 16.3.1.5 (Train Depart Local Control Console).

2. Contractor shall design and supply anti-vandalism enclosures for the Train Depart Local Control Console to prevent unauthorized access or tampering as described in Section 6.4.2 (Physical Security).

3. The Train Depart Local Control Consoles shall consist of pushbuttons to issue commands and a visual indication as specified in Section 16.3.1.5 (Train Depart Local Control Console).

4. The Train Depart Local Control Consoles shall not use keyboard and mouse input.

5. The Train Depart Local Control Consoles will be located outdoors. Contractor may provide electromechanical or electronic Equipment for the Train Depart Local Control Consoles which meet Contract requirements. The Train Depart Local Control Consoles shall be rated for exposure to water and outdoor environmental conditions.

6. Contractor shall design and supply power supplies, data communications and all other necessary Equipment to install and connect Train Depart Local Control Consoles with the CBTC System.

27.8.4.6 AUTOMATIC TURNBACK CONSOLE

1. Contractor shall supply four Automatic Turnback Consoles to be installed at Embarcadero and Chinatown platforms, as specified in Section 16.3.1.6 (Automatic Turnback Consoles).

2. Contractor shall supply an electromechanical console including at minimum:

    a. A pushbutton to activate the Automatic Turnback function

    b. An emergency stop pushbutton to stop the Train in case of emergency.

3. The Automatic Turnback Consoles will be located on publicly accessible platforms. To prevent unauthorized access or tampering when not in use, the Automatic Turnback Consoles shall be comprised only of physical pushbuttons.

4. Contractor shall design and supply anti-vandalism enclosures for the Automatic Turnback Consoles as described in Section 6.4.2 (Physical Security).

5. Contractor may co-locate the two Automatic Turnback Consoles at Embarcadero Station with the Train Depart Local Control Consoles at that station. Contractor shall explain the design decision to SFMTA during the Design Phase.

27.9 CBTC ON-BOARD EQUIPMENT REQUIREMENTS

1. Contractor shall follow the onboard Equipment Migration requirements as described in Section 24.8 (Migration).

2. Contractor shall design, Furnish and test the Vital and non-Vital relays and switches and all other necessary provisions as described in Section 31.7.4 (Vehicle Acceptance Testing).

3. Contractor shall design, Furnish and test a functional interface between the CBTC onboard subsystem and:

    a. The existing Train Operator Display (TOD)

    b. The existing Trainlines

    c. The existing Siemens train management Software through the Multifunction Vehicle Bus (MVB)

4. Contractor shall design, Furnish and test mode selection switch which has four positions as specified in Section 24.3 (Grades of Operation and Operating Modes) and Section 22.5 (Operating Mode Selection) to replace the existing mode selection switch.

5. Contractor shall include the Hardware mechanical design, catalog cut sheets, equipment specification sheets, circuit diagrams, tabulation of all units, assemblies, subassemblies, and parts in the Hardware Design Description (HDD) Document specified in Section 27.12 (Equipment CDRLs)

27.10 CBTC DATA COMMUNICATION SYSTEM (DCS) EQUIPMENT

1. Contractor shall supply the following DCS Equipment, at a minimum:

a. Wireless connectivity Equipment such as radios and antennas.

b. Network Equipment such as switches and routers.

c. Cabling and power supplies required for the operation of the DCS Equipment.

d. Other equipment necessary to comply with the requirement specified herein and in Section 26

2. The wayside and onboard radios and antennas shall have wireless connectivity for CBTC operation.

3. The onboard radio Equipment shall meet all requirements set herein while traveling at the maximum operational speeds described in Section 16.4 (Performance Requirements).

4. The wireless Equipment mounting shall not interfere with Vehicle operation.

5. The Vehicle and wayside mounted Equipment shall be installed such that it meets all clearance requirements specified in CPUC General Order 143B, Section 9 between the Vehicle and tunnel, or clearance between Vehicle and street level infrastructure. Equipment may be mounted on Overhead Catenary System poles if these clearance requirements are met.

6. The DCS Equipment shall:

   a. Meet TIA-942 tier 2 certification as a minimum for Equipment provided by Contractor.

   b. Enable deployment into standard datacenter computer racks for where proprietary DCS Equipment is utilized regardless of location installed.

7. All DCS Equipment shall have sufficient performance to minimize the potential from interference from other radio systems in SFMTA.

8. All field-installed switches and network equipment shall be rugged type.

9. Unless otherwise approved by SFMTA, all DCS Equipment and material furnished under this Contract shall comply with all requirements for a Class C environment (wayside signal enclosure) as specified by Section 11.5.1 of the AREMA C&S Manual and specified in Section 7.9 (CBTC Equipment Standards) of this Contract.

10. All DCS Equipment and material furnished under this Contract shall comply with any other environmental requirements stated elsewhere in these Contract Specifications if those requirements are more restrictive than the AREMA Manual.

11. All radio antenna poles for outdoor use shall consist of the step fold-down type to eliminate personnel having to climb or use work platforms during installation and testing of antennas, power dividers, and cables.

12. All new fiber optic cables shall have 50% spare capacity.

13. Contractor shall design and supply managed switches capable of a minimum of 1000Base-X (Gigabit) on every port (including fiber optic ports) for any Ethernet switches provided in the field.

14. All Ethernet switches and routers provided by Contractor shall have at least 50% of the Ethernet ports, or 4 Ethernet ports, whichever is greater, free at the time of Final Acceptance.

15. 25% of the free ports of any Contractor-supplied switches shall comply with Power over Ethernet Plus Plus (PoE++/4PPoE Type 4: 71.3W per IEEE 802.3bt-201).

16. The following Hardware requirements apply to provision of the CBTC Radio Data Communications subsystem:

    a. The Radio shall have a management console function, permitting a technician to connect a laptop computer to troubleshoot, make updates, or download Configuration information.

    b. Contractor shall design and implement visual alerts to include, but not limited to, Power On, RF Transmit, and RF Receive.

    c. Contractor shall design the Wireless Network System to be fully operational on SFMTA provided power or commercial power with battery backup.

17. The DCS Equipment shall meet the following environmental requirements:

    a. Ruggedized Radio connectors in accordance with industry specifications ISO 4523, MIL STD-1344, and MIL STD 810

    b. Provide a statement of conformance to the AREMA C&S Manual test for conducted emissions, surge withstanding capability, dielectric strength test, and tests of immunity to conducted disturbances and radio emissions.

    c. Convection Radio cooling only. No fans permitted.

    d. The Radio shall comply with AREMA Manual Part 11.5.1 and Military Specification 810.

    e. Operating Temperature Range shall meet or exceed the range of -40 degrees C to +70 degrees C.

    f. Operation in 90% minimum humidity at 40 degrees C, non-condensing.

    g. Transmit Duty Cycle shall meet the following parameters:

        i. Mobile: 100% at +70 degrees C.

        ii. Base: 100% at +70 degrees C.

    h. The Radio shall enable operation in an environment of airborne steel dust and high particulate content.

    i. Electromagnetic Compatibility for Radio shall comply with the following:

        i. Radiated Emissions per FCC part 15, class A levels from 30 MHz to 6 GHz.

        ii. Conducted Emissions per FCC part 15, class A levels from 0.15 MHz to 30 MHz.

    j. EMI immunity for Mobile Radio shall comply with IEC 61000-4-2 thru IEC 61000-4-6 inclusive, Performance Criteria B.

18. The following requirements apply to DCS grounding and lightning protection systems:

    a. The coaxial cable Grounding Kit shall comply with the cable manufacturer recommendation.

    b. The coaxial cable shield shall ground to the catenary structure prior to the cable entering the conduit and the radio house where applicable.

    c. The down conductor shall locate on the opposite side from the coaxial cable.

d. The down conductor shall tie into a ground rod at the base of the pole which may be connected to the radio house ground ring if the closest ground rod is less than 25 feet from the ground rod at the pole.

e. The ground rod shall have a minimum of 2 feet from the antenna pole.

27.11 EQUIPMENT HANDLING

27.11.1 BARCODE

1. SFMTA is in the process of implementing a barcoding system. Contractor shall review the Barcoding Procedures provided in Appendix J (SFMTA Policies and Procedures).

2. Contractor shall provide barcoding for CBTC parts and components that is compatible with the SFMTA's barcoding system for all CBTC parts and components.

3. Contractor shall submit a Barcoding Plan [CDRL] describing the use and integration of Contractors barcoding design into SFMTA barcoding system.

4. Contractor shall specify which parts (within the List of Parts) shall have bar codes affixed.

5. From the List of Parts and the asset registers specified in this Section, Contractor shall generate and provide barcode identification numbers, which may contain at minimum, SFMTA part numbers, unit numbers, part description, and/or asset management system generated numbers.

6. Contractor shall create the corresponding barcodes and affix onto each part provided to SFMTA.

7. Barcoding is required for all LRU, LLRU and Special Tools.

27.11.2 PACKAGING

1. Contractor shall securely pack in boxes, all parts, Special Tools, and test equipment as specified by the product requirements.

2. Contractor shall clearly label boxes with the location and description of the Equipment and the item, complete listing of all items in the box, and the quantity of each item included in the box.

27.11.3 DELIVERY

1. SFMTA will provide to Contractor a delivery notice with SFMTA assigned part numbers and designated delivery locations for all Contractor delivered items.

2. Contractor shall deliver all Materials in undamaged condition, in the manufacturers' original containers or packaging, with identifying labels intact and legible to a location, to be designated by SFMTA. SFMTA may instruct Contractor to deliver to one of SFMTA's facilities or to SFMTA's Installer. Contractor is responsible for the condition of Equipment and Materials until the delivery has been accepted by SFMTA.

3. Contractor shall deliver Equipment with the manufacturer's part number, description, shelf life if applicable, with packaging that is clearly labelled with information matching the entry in the List of Parts.

4. Contractor shall prepare and submit a packing list which includes SFMTA part numbers and bar codes.

5. Contractor shall submit an advance shipping notification to SFMTA representative 30 Days prior to shipping.

6. Contractor shall propose a delivery and receipt process that allows for the efficient delivery to SFMTA facilities and SFMTA's Installers, including necessary incoming quality control efforts and incorporation into SFMTA operational environment.

7. Contractor shall describe the delivery and receipt process in the Project Management Plan, Warranty Plan and Procedures, and the Support Management Plan.

8. Contractor shall include methodology to prepare formal receipts for all such delivered products in the delivery and receipt process.

    a. The methodology shall include SFMTA-assigned part numbers, purchase order information, quantity of parts delivered, unit cost, total cost, and tax as required by SFMTA.

    b. Contractor shall submit a copy of all such receipts to SFMTA for information and record.

9. For Materials and Equipment delivered as part of the System Procurement, excluding Warranty and Spare Parts, Contractor shall deliver all Materials and Equipment "just in time", meaning within the delivery window specified in the Project Management Plan relative to the date specified in the Project Schedule. SFMTA will not accept deliveries before the start of the delivery window. Liquidated Damages for Late Delivery apply to deliveries after the delivery window as described in Section 5.18.11 of the Agreement.

27.11.4 STORAGE

1. Contractor shall temporarily store Materials and Equipment that have arrived in the San Francisco Bay Area but have not yet been delivered to the SFMTA at its warehouses so that it is delivered "just in time" as described in Section 27.11.3 (Delivery).

2. Contractor shall not store undelivered Materials and Equipment on SFMTA premises.

27.11.5 SAFETY DATA SHEETS

1. Contractor shall Furnish Safety Data Sheets (SDS) [CDRL] for all Materials to be incorporated in the CBTC System (refer to the Hazard Communication Standard (HCS) 29 CFR 1910.1200(g)).

2. Contractor shall post the SDS for material that is flammable or otherwise Hazardous on a bulletin board provided for this specific purpose.

3. Contractor shall locate the bulletin board at the jobsite, accessible to all personnel engaged in the CBTC System Work.

27.12 EQUIPMENT CDRLS

27.12.1 HARDWARE DESIGN DESCRIPTION

1. Contractor shall submit a Hardware Design Description (HDD) package [CDRL] that describes the CBTC Hardware and Configuration covering all types of Equipment to the LRU level.

2. Contractor shall identify any adaptation from service proven Equipment in these documents.

3. Contractor shall describe all modifications necessary to make the service proven Equipment compliant with the requirements in these Contract Specifications.

4. The Hardware Design Descriptions shall include:

    a. All Equipment used and its functions

    b. Detailed Hardware interfaces (e.g. weights, dimensions, access, and mounting points; for Vehicle Hardware this may include center of gravity.)

    c. Equipment arrangement, layout, wiring diagrams, block diagrams and outline Drawings

    d. Firmware Configuration

    e. Datasheets for Equipment proposed

    f. Actual and maximum power calculated from each Equipment proposed

    g. Heating and cooling evaluations and analysis.

    h. Electromagnetic Compatibility requirements

    i. Environmental compliance analysis.

Table 27-27: Equipment CDRL Table

CDRL #	CDRL Title
27.01	Workstations Human Factor Analysis
27.02	Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) Program Plan
27.03	EMI/RFI Survey Plan
27.04	EMI/RFI Survey Report
27.05	Primary Control Center Floor Plan
27.06	Backup Control Center Floor Plan
27.07	Server Room Layouts
27.08	Control Center Workstations Layout
27.09	Wayside Signal Equipment Room Layout
27.10	Hardware Design Description

28 INTERFACE REQUIREMENTS SPECIFICATIONS

28.1 PURPOSE

1. This Section contains the interface requirements for the CBTC System. Contractor shall comply with the interface specifications set out in this Section and support integration of the CBTC System with SFMTA's and Third Parties' external systems.

28.2 GENERAL

1. System integration is a complex endeavor which requires the cooperation and engagement of all parties to reach a solution wherein the integrated systems meet the requirements contained in these Specifications. As the System owner, SFMTA will take the lead in integrating the CBTC System with SFMTA's Third-Party Systems (except onboard systems as described in Section 28.7) and shall direct the participation of Third-Party System vendors.

2. Contractor shall collaborate with SFMTA in integrating the CBTC System with SFMTA's Third-Party Systems that are listed in Section 28.3 (CBTC External Interfaces).

3. Contractor shall develop and submit Interface Control Documents (ICDs) as part of the System Design Documents, to describe in detail the management of external interfaces to the CBTC System, specifying:

    a. The data exchanged

    b. The functional requirements applicable to the interface

    c. The safety requirements applicable to the interface (i.e., Safety Critical, Safety Related, or non-Safety)

    d. The communication protocols

    e. Hardware, Software, and Configuration required for implementation and testing of the interface.

4. Contractor shall trace and include the requirements specified in the ICDs in Contractor Requirement Management Process.

5. Contractor shall include temporary interfaces (i.e., Cutover Cubicle) as part of the ICD package, including the decommissioning activities related to the cutover plan.

28.3 CBTC EXTERNAL INTERFACES

1. SFMTA will be the lead integrator between the CBTC and non-Vehicle Third-Party Systems. Contractor shall support SFMTA in the development of Contractor's CBTC System interface with SFMTA's existing Third-Party Systems described in the Table below.

2. Contractor shall develop and provide all necessary CBTC Software applications to support the interface determined by SFMTA.

3. Contractor shall offer its standard interface to SFMTA and furnish SFMTA with a description of its standard interface including its specifications, fields, parameters and definitions during the System Design Phase.

4. SFMTA will provide Contractor with Interface Control Documents for the Third-Party Systems for which SFMTA is to perform the integration and work with Contractor to establish what data can be obtained through Contractor's standard interfaces and what data requires a Customization of Contractor's interfaces to obtain. Contractor shall modify its standard interface or develop alternate interfaces as specified in the approved design.

5. SFMTA will build interfaces to Third-Party Systems including any necessary middleware and format conversions. Contractor shall collaborate with SFMTA to achieve the required functionality by ensuring its System transmits the data required using the SFMTA approved interface.

6. Contractor shall lead the integration between the CBTC onboard subsystems and the Siemens systems onboard the LRV4 that are necessary to meet Contract requirements and approved designs.

7. Table 28-1 specifies interfaces which are described further in this Section. The Reference Materials contain more information on SFMTA and Third-Party Systems referenced in this Section. SFMTA will furnish additional information to the Contractor as needed during the Design Phase.

Table 28-28: External Interface Summary

External Interfaces	Existing Future	SFMTA/ Third Party	Vendor	Safety Critical	API
Central					
Video Wall	Existing	Third-Party	BARCO, Creston, AVI-SPL	No	No
Data warehouse	Existing	SFMTA	To be provided	No	Yes
Enterprise Asset Management System (EAMS)	Existing	SFMTA/Third-Party	Infor	No	Yes
Customer Information System – UmoIQ*	Existing	SFMTA/Third-Party	Cubic	No	Yes
CAD/AVL System (OrbCAD)	Existing	SFMTA/Third-Party	Conduent	No	Yes
Platform Audio Visual (PAV) signs and announcements	Existing	SFMTA/Third-Party	Penta/Daktronics	No	Yes
Supervisory Control and Data Acquisition (SCADA)	Existing	SFMTA	TBD	No	Yes
Onboard					
LRV4	Existing	Third-Party	Siemens	Yes	No
Wayside					
Traffic Control System	Existing	SFMTA/ Third-Party	Fourth Dimension Traffic	No	No
Drawbridges/Freight Crossings	Existing	SFMTA	Various	Yes	No

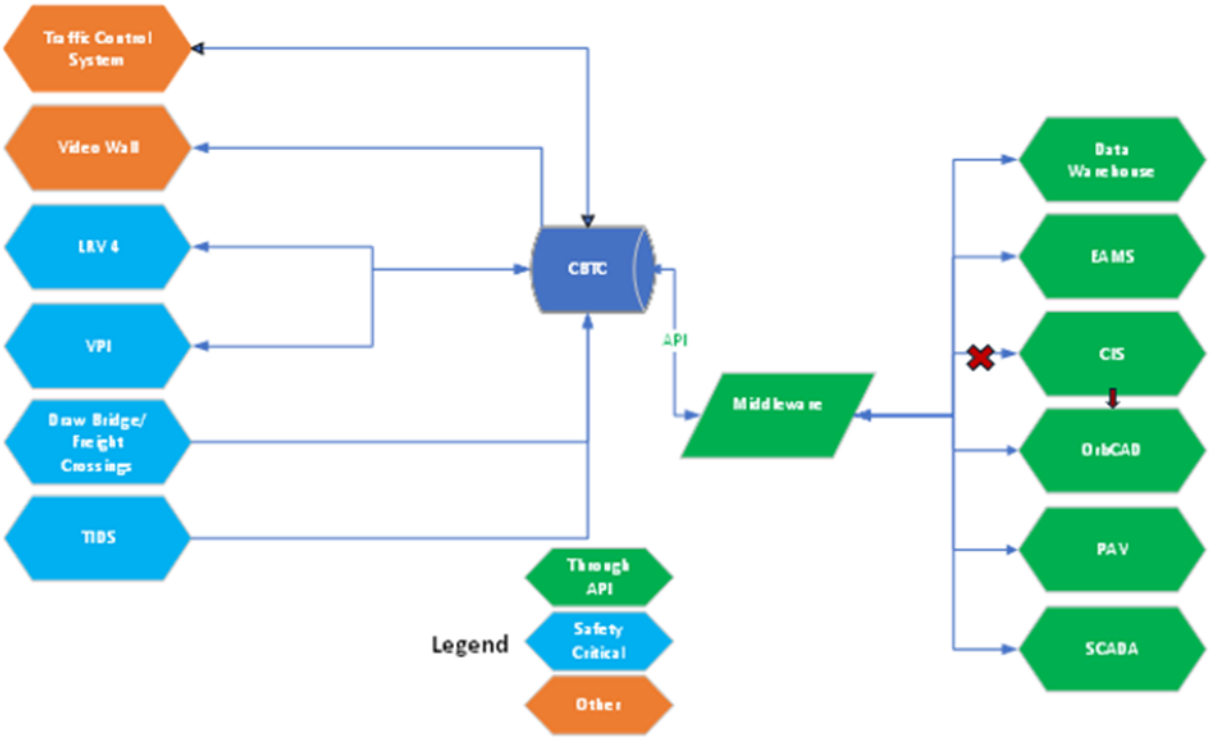
External Interfaces	Existing Future	SFMTA/ Third Party	Vendor	Safety Critical	API
Track Intrusion Detection System (TIDS)	Existing	SFMTA/Third party (TBD)	Genetec/TBD	Yes	No

*Not directly interfaced with CBTC.

28.4 APPLICATION PROGRAMMING INTERFACE

1. Contractor shall develop Application Programming Interface (API) Software to interface with the following subsystems:
    a. Data Warehouse
    b. Enterprise Asset Management System (Infor EAMS)
    c. CAD/AVL – Conduent OrbCAD
    d. Platform Audio Visual (PAV) signs and announcements
    e. SCADA
2. The API shall not directly interface with the Cubic UmoIQ Customer Information System. The Customer Information System will obtain data originating from the CBTC through an integration with the CAD/AVL system. However, this system is included in Table 28-1 because it may have data needs which drive interface requirements for the integration between the CBTC System and the CAD/AVL system.
3. Figure 28-1 shows the planned architecture of the interface between the CBTC System and SFMTA external systems. The middleware is not part of Contractor's scope. Contractor may propose an alternative architecture subject to SFMTA review and approval.
4. Contractor shall develop API for batch data and API for real-time transmission.

Figure 28-4: Example of CBTC External Interface



5. Contractor shall submit a list of Published APIs [CDRL] as part of the System Design Documents should the data from the CBTC System require multiple published APIs.

6. The CBTC System Published API shall work with SFMTA existing systems.

7. The CBTC System Published API shall comply with industry Standards, and SFMTA Standards (RESTful), that are developer-friendly, easily accessible, and broadly understood.

8. Contractor shall submit the industry Standards applicable to the CBTC System Published API for to the SFMTA for reference in the API Design Document.

9. Contractor shall describe, in collaboration and agreement with SFMTA, the rules, structures and constraints that will govern the operation of the published API in an API Design Document [CDRL] that shall be included as part of the System Design Documents.

10. The API Design Document shall include:

    a. The architecture of the published API

    b. A list of all data (real-time, maintenance, and diagnostic, storage) to be provided to existing SFMTA systems through this API. Contractor shall further refine this list of data with additional input from SFMTA, in collaboration, and in agreement with SFMTA during the design Phase.

    c. A list of data, if any, that is required by the CBTC System from existing SFMTA systems through this API.

28.4.1 DATA WAREHOUSE

1. The Data Warehouse is a SFMTA system used to collect and analyze operation and diagnostic data and for long term data storage.

2. Contractor shall adapt its API as necessary to support the transmission of CBTC System data to the Data Warehouse so that the Data Warehouse functions as a mirror of the applicable CBTC System databases.

3. To reduce risks to the CBTC System, queries for performance analysis purposes shall be made on the data stored in the Data Warehouse as opposed to the data stored in CBTC System databases.

4. Contractor's analytics platform shall interface with the SFMTA Data Warehouse.

5. The CBTC System shall access information from the Data Warehouse if needed to meet requirements in these Contract Specifications.

6. Contractor shall share all data that could be shared via API to the Data Warehouse. This data does not need to be in real-time (batch data transmission) but configured in a timely manner subject to SFMTA review and approval. This includes but not limited to:

    a. Logs.

    b. Stored commands.

    c. Alerts and alarms.

    d. System Performance data.

    e. Configuration information.

7. Contractor shall further refine this list in collaboration and agreement with SFMTA.

8. The list of data to be exchanged with the Data Warehouse shall be submitted as part of the API Design Document [CDRL].

28.4.2 ENTERPRISE ASSET MANAGEMENT SYSTEM (EAMS)

1. EAMS is an SFMTA maintenance system used to manage assets, work orders, Materials (parts and spares), and record maintenance actions.

2. The CBTC Asset Management System (AMS) shall interface with EAMS to provide diagnostics and maintenance related information, including but not limited to:

    a. Status of Equipment

    b. Part numbers, defect details, system, and location of failed Equipment

    c. Plans, Assembly layouts and detailed Hardware Drawings to be attached to repairs or replacement work orders

    d. Preventive Maintenance alerts and instructions

3. The information provided to EAMS, identified as described in this Section, shall be kept current at all times such that it is always synchronized with AMS. Contractor may use different means of transmission, such as APIs etc., for different datasets as needed to meet this requirement.

4. Contractor shall further refine this list in collaboration and agreement with SFMTA

5. Contractor shall submit a list of data to be exchanged with the EAMS as part of the API Design Document [CDRL].

28.4.3 REAL TIME PREDICTION SYSTEM – CUSTOMER INFORMATION SYSTEM

1. Contractor shall interface with the Customer Information System via real-time API to properly initiate the train arrival prediction messages at the platform in the surface territories.

2. The CBTC System shall transmit to the Customer Information System the arrival time prediction of the next two Trains per Service Line at each platform.

3. Contractor shall further refine the information transmitted between the CBTC System to the Customer Information System in collaboration and agreement with SFMTA and include the details in the API Design Document [CDRL].

28.4.4 COMPUTER AIDED DISPATCH (ORBCAD)

1. The CBTC System shall have a bidirectional interface to the Computer Aided Dispatch / Automatic Vehicle Location (CAD/AVL) system via real-time API.

2. The CBTC shall transmit to OrbCAD, at a minimum:

    a. Train locations,

    b. The current trip for each Train,

    c. Routing,

    d. The car numbers which make up the Consist,

    e. Train block assignments made in the ATS System,

    f. Train hold status, including expected duration of hold, and Dwell Time remaining,

    g. Schedule updates made by Transportation Controllers in the ATS subsystem as described in Section 17.5.2 (ATS Schedule Management Function).

    h. Schedule and service adjustments made by Transportation Controllers in the ATS subsystem as described in Section 17.3.4 (Incident Mitigation Functions).

3. The CBTC System shall receive from OrbCAD, at a minimum:

    a. Planned schedule for the day

    b. Train timetables

    c. Train block assignments based on OrbCAD login information

4. Contractor shall further refine this list in collaboration and agreement with SFMTA during the Design Phase.

5. The daily schedule and Train Block assignments can be modified both in OrbCAD and in the CBTC ATS System. Contractor shall design the interface and operating procedures to keep both systems in sync at all times, regardless of in which system the modification was initiated.

6. Contractor shall submit a list of data to be exchanged with OrbCAD as part of the API Design Document [CDRL].

28.4.5 PLATFORM AUDIO VISUAL (PAV)

1. The CBTC System shall interface with the PAV system via a real-time API to properly initiate the train arrival and destination messages at the platform in the tunnel territories.

2. The CBTC System shall transmit to PAV the arrival time prediction of the next two Trains per Service Line at each platform and the Train destination.

3. Contractor shall include the details of the PAV interface in the API Design Document [CDRL].

28.5 VIDEOWALL

1. The ATS subsystem shall have a functional interface with the videowalls the Primary and backup Control Centers and to display the CBTC System Line Overview as specified in Section 17.

2. Contractor shall submit a Videowall ICD [CDRL] as part of the System Design Documents.

28.5.1 PRIMARY CONTROL CENTER

1. The ATS subsystem of the primary Control Center at the Transit Management Center (TMC) shall interface to an existing videowall used by the Transportation Controllers in the operations theater. The videowall system interface is a Digital Visual Interface (DVI) technology and is made of several components provided by BARCO and Creston) and integrated by AVI-SPL.

28.5.2 BACKUP CONTROL CENTER

1. Contractor shall supply in the backup Control Center (OCC, 131 Lenox Way) a new videowall of the same technology as the primary Control Center (TMC).

2. Contractor shall duplicate the interface between the ATS and the videowall at TMC and provide that duplicated interface for OCC.

28.6 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

1. The CBTC System shall interface with SCADA via a real-time API to receive Traction Power Status from the Overhead Catenary System (OCS) and display it on the ATS workstation.

2. The ATS subsystem shall utilize the information it obtains from SCADA to:

    a. Limit the number of LRVs in a traction power section to reduce the possibility of an OCS overload, and

    b. Prevent Trains from entering a traction power section track with OCS power outage.

3. Contractor shall adapt its API as necessary to support the SFMTA's integration of the CBTC System and SCADA and accomplish the requirements in these Contract Specifications.

28.7 ONBOARD INTERFACE

1. The CBTC System shall interface with the LRV4 Vehicles through electrical interface (Trainlines) and Software interface through a Multifunction Vehicle Bus (MVB), as specified in Section 24 and in the CBTC Rolling Stock Electrical Interface provided by SFMTA.

28.8 TRAFFIC SIGNAL CONTROLLER

1. Traffic Signal Controllers (TSC) are used to control automobile traffic signals on San Francisco's streets. San Francisco uses 2070 TSCs with software are provided by Fourth Dimension Traffic (D4) and are considered a mix between an SFMTA System and Third- Party System because SFMTA has the capability to Configure those controllers. SFMTA uses one 2070 TSC to control each signalized road intersection.

2. Any change to the TSC, such as changes to its software configuration or logic shall be carried out by Fourth Dimension Traffic under direction from SFMTA. Information about the Traffic Signal Controllers is included in the Reference Materials. SFMTA will furnish additional information as needed during the Design Phase.

3. Contractor shall design and implement a functional interface to each Traffic Signal Controller using a real time network IP based interface which shall transmit the expected arrival time (in seconds) of the next 3 Revenue Service Vehicles at each intersection in both directions.

4. The CBTC System shall use travel time history collected by the System as the basis for calculating the expected arrival times furnished to the TSC.

5. Contractor's arrival time calculation algorithm shall consider travel times at similar times of the day, days of the week, and months of the year in addition to the travel times of the previous trip and recently made trips.

6. Contractor's analytics tool shall provide an assessment of the accuracy of these arrival time calculations by comparing the predicted arrival time 2,200 ft, 11,000 ft and 22,000 ft away from the intersection to the actual arrival time logged by the CBTC System.

7. 90% of predicted arrival times shall be accurate within the following tolerances:

    a. +/- 5 seconds for predictions made 2,200 ft from the intersection

    b. +/- 25 seconds for predictions made 11,000 ft from the intersection

    c. +/- 50 seconds for predictions made 22,000 ft from the intersection

8. The CBTC System shall receive real-time information such as the current signal phase and configuration information such as signal cycle configurations from the Traffic Signal Controller through the interface.

9. The CBTC System shall communicate with the TSC using the National Transportation Communications for ITS Protocol (NTCIP) or the Standard Communications Protocol for Traffic Signals in California (AB3418).

10. Messages transmitted to/from the Traffic Signal Controllers shall be compatible with the Fourth Dimension Traffic software objects described in the Traffic Signal Communication Protocol included in the Reference Materials.

11. Messages shall be transmitted to the Traffic Signal Controllers a minimum of once per second. The Traffic Signal Controllers will use this information to give priority to Vehicles over automobile traffic.

12. For the intersections with CBTC Interlocking where both a TSC and transit signal are present, the TSC and the transit signal shall have a handshake communication to ensure coordination of permissive and restrictive signal aspects ahead of Vehicle arrival.

13. The ZC shall a ensure a restrictive aspect is presented under failure conditions of the interface between the TSC and Interlocking as a Safety Critical failsafe.

14. The CBTC System shall represent the upcoming traffic signal phase on the Train Operator Display (TOD).

15. The Contractor shall design this TOD feature so that the SFMTA can Configure the System to hide this upcoming traffic signal phase display.

16. The CBTC System shall use information received from the TSC to as an input to the train regulation function, adjusting recommended speeds and Dwells based on the information received so that Vehicles arrive on a green traffic signal.

17. Contractor shall submit the TSC ICD [CDRL] as part of the System Design Documents.

28.9 DRAWBRIDGES

1. The Muni Metro light rail system crosses two Drawbridges. They are equipped with sensors and Programmable Logic Controllers (PLC). The authorization process and detection of bridge alignment or misalignment are performed by the sensors and the PLC. Information about the Drawbridges is included in the Reference Materials. SFMTA will furnish additional information as needed during the Design Phase.

2. Contractor shall design and implement a safety critical interface with the existing Drawbridge Interlocking or alternatively propose a replacement solution.

3. Contractor shall submit the Drawbridge ICD [CDRL] as part of the System Design Documents.

28.10 FREIGHT CROSSING

1. A Freight railway crosses Third Street and the accompanying SFMTA light rail tracks in two locations. The Freight Crossing (FC) is controlled by Alstom VPI Interlockings owned by SFMTA, which provides the status of the freight train signal protecting the intersection to SFMTA's signals. Contractor shall design and furnish replacement Interlockings for the Freight Crossings which are integrated with the CBTC System.

2. The Freight Crossing Interlocking and integration shall allow Trains to request routes through the Freight Crossings and shall get confirmation from the freight train signal before allowing a Train to enter the intersection.

3. The ZC shall a ensure a restrictive aspect is presented under failure conditions of the interface between the Freight Crossing and CBTC System as a Safety Critical failsafe.

4. Contractor shall submit the FC ICD [CDRL] as part of the System Design Documents.

28.11 TRACK INTRUSION DETECTION SYSTEM

1. SFMTA is currently equipped with two types of Track Intrusion Detection System (TIDS) one of which is LiDAR Genetec Restricted Security Area (RSA) and the other type is legacy LiDAR covering the portal areas.

2. Contractor shall design the CBTC System to vitally interface (through Discrete I/O) with the current Genetec RSA LiDAR System to detect intrusion in UTO Territory at Muni Metro Turnback (MMT).

3. In addition to the Safety Critical interface, the CBTC System shall send the status of the Intrusion System to SFMTA through real-time API.

4. Contractor shall design the CBTC System to vitally interface (through Discrete I/O) with legacy LiDAR at the portal, central and closely associated tracks once intrusion is detected.

5. The CBTC System shall close the tracks in the area where the intrusion is detected.

6. The CBTC System shall disable Automatic Turnback when an intrusion is detected in MMT UTO Territory in accordance with the requirements in Section 18.7 (Automatic Turnback).

7. CBTC System shall display an alarm on the ATS GUI and on the TODs of affected Trains which indicates an intrusion detection.

8. In addition to the Vital interface, the CBTC System shall send the status of the intrusion System to SFMTA through real-time API.

9. The design of the CBTC System interface with the TIDS shall ensure Fail-Safe reaction in case of interface failure.

10. Contractor shall submit the TIDS ICD [CDRL] as part of System Design Documents.

28.12 INTERFACE REQUIREMENTS SPECIFICATIONS CDRLS

Table 28-29: Interface Requirements Specifications CDRL Table

CDRL #	CDRL Title
28.01	Application Programmable Interface (API) Design Document
28.02	List of Published APIs
28.03	Interface Control Document (ICD) - Video Wall Display
28.05	ICD - Traffic Signal Controller (TSC)
28.06	ICD - Drawbridge
28.07	ICD - Freight Crossing (FC)
28.08	ICD - Track Intrusion Detection System (TIDS)

29 DEMOLITION AND DISPOSAL

29.1 PURPOSE

1. This Section specifies Contractor obligations to provide Installers with comprehensive instructions and documentation to perform Demolition and Disposal work in compliance SFMTA requirements herein expressed, as part of the CBTC Deployment.

29.2 DEMOLITION, REMOVAL AND DISPOSAL PLAN

1. Contractor shall prepare and submit a Demolition, Removal, and Disposal Plan [CDRL] which describes the removal of decommissioned central, wayside and onboard train control equipment, and related decommissioned infrastructure following the final cutover and commissioning of the CBTC System. The SFMTA will use this plan to direct the Installer to perform this work.

2. Contractor shall submit Demolition and Disposal plans and procedures for Installer to perform demolition as required for each of the following:

    a. Control Center Facilities

    b. Central Equipment Rooms

    c. Wayside Equipment Rooms

    d. Wayside Equipment

    e. Vehicle Equipment

    f. All other dismissed legacy train control equipped and infrastructure

3. The Demolition, Removal, and Disposal Plan shall describe risks and mitigations for demolition, removal, and disposal where these activities have the potential to impact operations or SFMTA equipment or facilities.

4. The Demolition, Removal, and Disposal Plan shall describe opportunities for reuse of removed equipment by SFMTA.

5. Contractor shall include the following elements in the procedures:

    a. Protections and procedures used to ensure safety during entire demolition, removal, and disposal process

        i. Description of quantity and application of expected Installer personnel and materials

        ii. Identification of Proprietary Tools which may be required

        iii. Procedure to protect Equipment, Devices, Appurtenances, and other adjacent material

    b. Site specific detailed equipment and layout arrangement plan for removal of existing wayside equipment (indoor and outdoor) including the following:

        i. Train control facility

        ii. Trackside equipment

        iii. Platform equipment

        iv. Unused cables and conduits

c. Details of coordination between the Installer and SFMTA for trackside elements installed between the rails.

d. List of the existing signal System equipment to be removed and the timing of removal.

e. On-rail Vehicle specific obsolete equipment removal and disposal details, including CBTC final Configuration Drawings.

f. Project Schedule including stages and durations of demolition, removal, disposal, and specified timing after decommissioning of existing train control equipment.

g. Establish conditions for demolition, removal, and disposal of existing train control equipment.

h. Provide details and documentation for the installation and removal of any Contractor-installed/requested Wi-Fi networks used during the construction process prior to installing such equipment. Include Service Set Identifier (SSID) used and security protocols used. At removal, provide details documenting disablement.

6. Final Demolition and Disposal plans and procedures shall be submitted as part of the Construction Documents for each Phase.

7. Demolition and Disposal plans and procedures shall be reviewed, compared to the as-built drawings, and updated following successful PICO testing for each Phase.

29.3 DEMOLITION AND DISPOSAL CDRLS

Table 29-30: Demolition and Disposal CDRL Table

CDRL #	CDRL Title
29.01	Demolition, Removal and Disposal Plan

30 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM)

30.1 PURPOSE

1. This Section provides the Reliability, Availability and Maintainability (RAM) Requirements for the CBTC System.

30.2 QUALITATIVE RAM OBJECTIVES AND REQUIREMENTS

1. The CBTC System shall have overall System Availability (A_s) targets specified in Appendix I to the Agreement.

2. All CBTC subsystems and components shall exhibit the Reliability and the numerical objectives specified in Appendix I to the Agreement.

3. To support overall System Availability, Contractor shall design a "Fail-Safe" and also a "Fail-Operational" CBTC System to the maximum degree practical.

4. "Fail-Operational" means that the System shall remain fault tolerant and shall continue to operate, unless the safety of persons, the environment or adjacent equipment are endangered to any extent, as per the requirement of "Fail-Safe".

5. Contractor shall develop a Fault Tree Analysis Diagram [CDRL] that relates both "Fail-Safe" and "Fail-Operational" objectives as specified in Section 6 (System Safety and Security Management) and in this Section.

6. The Fault Tree Analysis Diagram shall show how the Reliability objectives are attained while the System maintains acceptable Safety and Operational targets.

7. Contractor shall develop a Fault Tree Analysis [CDRL], which shall:

    a. Demonstrate correct modeling of the CBTC System under review starting from top level CBTC Hazards down to the lowest quantifiable base event level. A narrative and listing of assumptions and the analytic techniques used to generate the fault tree shall accompany the Fault Tree Analysis. Contractor shall prepare the Fault Tree Analysis according to the Standards specified in Section 7 (Codes and Standards).

    b. Describe top events which directly or indirectly lead to: Service Affecting Failure, Significant Failure and Reduction in Operating Margin.

    c. Explain the types of faults considered part of the CBTC and those, which are external to the CBTC, if any.

    d. Describe and demonstrate the independence of events and assess the common causes, if any

    e. Reference the RAM requirements reused in the requirements analysis to augment the development of this analysis.

8. Contractor shall describe processes and functionalities of the CBTC System providing detection, management, mitigation, or failure elimination particularly those which may compromise or adversely influence the ability of the System to perform safely or reliably.

9. In addition to the Fault Tree Analysis (FTA), Contractor shall identify and analyse all possible failures via Software Failure Modes and Effects Analysis (FMEA) following the guidance included in IEC 60812 and IEEE 1633-2016.

30.2.1 FAILURE ALLOCATION AND CATEGORIZATION.

1. Contractor shall apportion for the proposed CBTC System and subsystems each of the numerical target parameters identified in Table 30-1 amongst the following categories of failure.

2. Contractor may propose overall System RAM Parameters (Availability, MTBF) that exceed those specified but shall not exceed requirements specified for MTTR and $MTTR_{max95}$).

3. A Service Affecting Failure (SAF) is specified as any failure which causes a delay to Revenue Service lasting more than 2 minutes. Any such faults that are reset within 2 minutes (by local or remote means) shall not count as a SAF, unless an identical fault reoccurs within one hour of the original fault occurrence.

4. A Loss of Critical Function (LCF) is specified as failures that do not impact Revenue Service on-time performance but result in loss of any ATS functionality (i.e., inability to implement a Temporary Speed Restriction (TSR), Close Tracks, or block Switches, supervise train operations, view faults/errors).

5. Reduction in Operating Margin (ROM) is specified as any other fault or failure that does not directly impact Revenue Service on-time performance, nor result in any loss of critical or other ATS function, but impacts the System's redundancy, introduces or increases the need for operational staff intervention or supervision, increases maintenance requirements or any other unplanned direct or indirect burden or operational restriction (i.e., loss of an onboard antenna).

6. Contractors shall identify a failure, including a Software Failure, as a 'Significant Failure' if the failure requires unplanned intervention by any authorized person acting on behalf of Contractor or on behalf of SFMTA, occurring in any product, system, or sub-system of any Hardware or Software, or functional failure in the CBTC System, resulting in any unscheduled or early withdrawal from Revenue Service (even if an on-time arrival at a mid-point or terminal destination is achieved).

7. If any reset action is necessary in excess of 5 minutes or any other manual intervention with the product or its output is deemed necessary to re-establish function or service that takes greater than 5 minutes, then Contractor shall also categorise the failure as 'Significant'.

8. Significant Failures shall not exceed 1% of the total of all failures.

9. If such manual intervention cannot or does not result in re-establishment of scheduled performance in 5 minutes or is recorded at a rate of occurrence greater that twice per hour, then Contractor shall categorise and record that failure as a "Service Affecting Failure", as specified above.

10. Contractor shall keep track and regularly publish the number of minutes lost to all failures, whether or not caused by Contractor.

    a. Contractor shall publish this data in an agreed format every accounting period and be aggregated on a yearly basis.

    b. Contractor shall record lost minutes caused by the CBTC System. These minutes are specified as Lost Minutes per Year (LMY).

11. The LMY shall aggregate lost minutes from all events leading to Service Affecting Failures greater than 2 minutes in duration.

12. In the event that one event leads to Consequential Events in multiple systems, then Contractor shall take the total lost time for all affected systems and Consequential Events in the aggregate.

13. The LMY shall be computed using the time individual revenue Vehicles spend stationary during a Service Affecting Failure. For example, if a complete System failure occurs such that all Vehicles are stopped for 15 minutes, the LMY would include 15 minutes multiplied by the number of Vehicles in service.

14. Contractor shall submit a Fault Tree or Reliability Block Diagram [CDRL] to demonstrate that the proportion of 'Significant' failures does not exceed 1% of the total of all failures identified.

15. Contractor shall submit the Fault Tree or Reliability Block Diagram at each design Milestone.

16. Contractor shall update the Fault Tree or Reliability Block Diagram at the commencement of each Deployment Phase.

17. Contractor shall submit full justification of the measures and techniques used to achieve compliance with the Performance Targets specified in the Appendix I to the Agreement through the submission of a RAMS Analysis described in this Section.

30.2.2 FAILURE REPORTING AND CORRECTIVE ACTION SYSTEM (FRACAS)

1. Contractor shall identify a capable and comprehensive process for recording and analyzing failures that occur in any Equipment or Software supplied by Contractor.

2. Contractor shall identify the means of collecting, organizing, and maintaining in-service Failure Data.

3. Contractor shall establish a "closed-loop" Failure Reporting and Corrective Action System (FRACAS) process that includes provisions for tracking problems, failures, analyses, and corrective actions.

4. Contractor shall have this System available for use prior to and during Software Testing, Test Running, during Trial Running or during any Shadow Timetable simulation and Revenue Service.

5. The FRACAS process shall include the interface of the CBTC AMS with SFMTA Enterprise Asset Management System (EAMS) to record and manage failure data.

6. The FRACAS shall record and analyze the nature of failures and repair or restorative corrective actions, the results of root-cause analysis and the corrective actions undertaken to improve Reliability from the start of Commissioning to the end of the Contract Term.

7. Anytime there are open items in the FRACAS process, Contractor shall hold regular failure status reviews where the status of corrective actions for all CBTC Issues and failures are presented to the SFMTA Project Manager or Owner's Representative for review.

8. Problem and failure closeout documentation shall be provided to the SFMTA Project Manager or Owner's Representative for review and approval.

9. The AMS shall manage the closed loop FRACAS process and store FRACAS information to its database. It shall contain the following features:

a. Failure Reporting (FR). The failures and the faults related to a system, an Equipment, a Software, or a process are formally reported through a standard form (Defect Report, Failure Report).

b. Analysis (A). Perform analysis to identify the Root Cause of failure.

c. Corrective Actions (CA). Identify, implement, and verify corrective actions to prevent further recurrence of the failure.

10. The information collected and stored in the FRACAS database shall as a minimum include:

a. Part Number

b. Part Name

c. OEM

d. Field MTBF, MTBR, MTTR,

e. Price

f. Purchase order number

g. Spares consumption

h. Original Reliability specification

i. Currently calculated Reliability

j. Failure/Incidents distribution by type

k. Failure location

l. Serial no

m. Symptom

n. Maintenance time

o. Maintainer ID

p. Root cause analysis

q. Date of Incident

r. Software and/or firmware version

s. Software update/upgrade and obsolescence status

t. Software anomaly type (Software Error, Defect, Software Fault, Software Failure and Software Problem as defined in Section 1.4.1 and Defects, and Failures attributed in the FRACAS database in accordance with IEEE Std 1044-2009)

30.2.2.1 FAILURE REVIEW BOARD (FRB)

1. The Failure Review Board (FRB) reviews RAM Performance, CBTC Issues and System failures occurring during the Contract Term. RAM Performance shall be calculated automatically by the FRACAS and AMS, compared to the Quantitative RAM Objectives, and used to determine the Monthly Service Payment as set out in Appendix B to the Agreement.

2. The FRB shall review:
    a. RAM Performance calculations
    b. System failures that are submitted for review by Contractor or SFMTA
    c. CBTC Issue Response and Resolution timing calculations submitted for review by Contractor or SFMTA
    d. Performance-Based Monthly Support Fee calculations, if disputed by SFMTA or Contractor
3. The FRB shall meet, at a minimum, on a quarterly basis to monitor and validate the calculation of CBTC System Performance Metrics, starting at the beginning of the Initial RAM Demonstration.
4. The FRB shall determine the cause, chargeability, and responsibility for all CBTC System failures that are brought before it.
5. Contractor shall prepare and submit to the Failure Review Board all failure details, summaries, metrics or other information necessary to determine the Root Cause and recommended disposition for action on all failures.
6. The FRB shall review Issue Response and Resolution timing calculations and decide questions related to the Issue response and resolution process set out in Appendix I to the Agreement, such as Issue Severity Level.
7. The FRB's determination is administratively binding, and Contractor shall use this determination within any Reliability or Availability calculations.
8. If Contractor refuses to accept the FRB's determination, this shall be considered a dispute to be resolved by the resolution procedures provided in Section 12.8 of the Agreement.
9. SFMTA will prepare and distribute agendas and minutes for each meeting.
10. The FRB shall contain the following five members:
    a. Chairperson (who is a representative of SFMTA and who holds a casting vote).
    b. Two FRB members shall represent Contractor's organization. Contractor shall identify these members.
    c. Two members from the SFMTA operations and maintenance organizations that work with the CBTC System. SFMTA will identify these members.

30.2.3 ROOT CAUSE ANALYSIS

1. Root Cause Analysis (RCA) is a thorough identification of the cause(s) of a failure in a systemic and documented process. It is performed for the purpose of discovering the precise cause(s) which led to the recorded failure condition. A Root Cause is any factor by which their removal would always and unconditionally prevent the occurrence or re-occurrence of the adverse event. Other factors that are unconnected with the adverse event are not be considered Root Causes.
2. Contractor shall conduct an RCA only once for any occurrence of the failure. Contractor shall complete the RCA, enter all information identified in Section 30.2.2, paragraph 5 into the FRACAS, and issue a Root Cause Disposition report to the SFMTA within the Target Root Cause Disposition times set out in Appendix I, Table 2

3. The Root Cause Disposition report shall contain at a minimum, all details of the failure, a summary of the root cause analysis that was performed, the causal factors considered, the Contractor's determination of the root cause, and the Contractor's reasoning for identifying the factor as the root cause.

4. Contractor shall conduct every RCA completely, rigorously and reasonably.

5. All RCAs shall remain in an "open" status until submitted by Contractor for approval by SFMTA.

6. If any failure recurs following the closure of an RCA, then Contractor shall reopen the previously associated RCA and further investigate the Root Cause based upon this trend data.

30.3 QUANTITATIVE RAM OBJECTIVES

1. Appendix I to the Agreement contains the RAM Performance Targets that Contractor shall adopt for RAM Demonstration and by which will be used to measure the RAM Performance during the Support Term of the Contract. The Performance Targets indicate the expected performance level.

2. Contractor shall use the values in Table 30-1 and Figure 30-1 as standing assumptions for the purposes of RAM calculations.

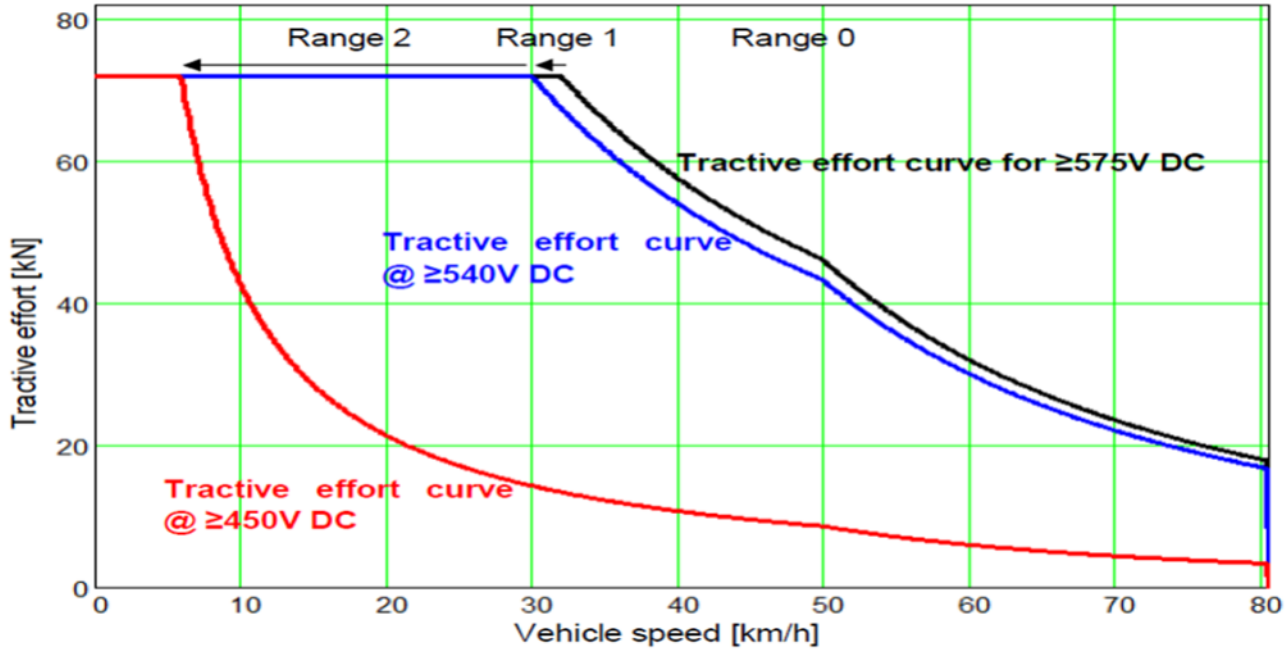
3. Contractor shall refer to the Concept of Operations and Maintenance in the Reference Materials for any assumptions not listed in this Section, such as service frequency.

Table 30-1: Standing Assumptions for RAM Calculations

Metric	Units
Operating Hours per day (M-F)	19 hours
Operating Hours per day (Sa)	18 hours
Operating Hours per day (Su)	16 hours
Conversion factor from time to distance (Average Speed), Surface	10 mph
Conversion Factor from time to distance (Average Speed), Subways	40 mph
Operational days / year	365 days
System design lifetime	20 years after Final Acceptance
Average Dwell Time	25 seconds
Consist length (J)	1 car
Consist length (K,L,M,T,S)	2 car
Consist length (N)	3 car
Travel time of maintenance crew to field location	40 minutes (peak), 25 minutes (off-peak)
Door opening time	4 seconds

Metric	Units
Door closing time	5.5 seconds
Switch throw duration	5 seconds
Service brake distance	3.5 mphps
Acceleration rate	Acceleration rate up to 20mph is 3 mphps
Brake response time	2.5 mphps2
Max jerk	3 mphps2
Wheel diameter (LRV)	28 inches
Wheel diameter (PCC streetcar)	25 inches
Wheel diameter (Milan streetcar)	28 inches
Wheel diameter (Freightliner maintenance truck)	15 inches
Wheel diameter (Ford F550 maintenance truck)	12 inches
Runtime reserves (at non-Embarcadero station terminals)	10 minutes

Figure 30-1: Tractive Effort Graph



4. SFMTA may revise these assumptions through change order as provided in Section 12.5 (Contract Modifications and Change Orders) of the Agreement during the Contract Term to reflect changes to SFMTA's operations.

30.4 MAINTAINABILITY

1. Contractor shall submit analyses and supporting calculations detailing how targets for the items identified below are used to achieve the revised Contractor Reliability and Availability targets specified in Appendix I to the Agreement:
    a. Mean Corrective Maintenance Time (MCMT).
    b. Maximum Mean Corrective Maintenance Time (MCMTmax95).
    c. Mean Time to Restore (MTRE).
    d. Maximum Preventive Maintenance Person-hours.
    e. Maximum Corrective Maintenance Person-hours.
2. Contractor shall submit these analyses prior to each design Milestone for review and approval and be updated prior to factory testing of any Equipment, prior to site acceptance testing and immediately following the final systems integration testing.
3. Contractor shall have remote System diagnostics to provide condition monitoring data and related information to maintenance and site staff in real time, using the Asset Management System (AMS) as described in Section 20.
4. The AMS shall offer a predictive analytical capability to pre-empt failures whenever practicable. This will ensure that failures and potential failures are identified and corrected as early as possible.
5. The AMS shall link to the EAMS System to facilitate the capture and processing of failure data directly and management of the inventory of available spares.
6. Contractor shall minimize the use of Special Tools, stand-alone test equipment or other similar equipment or provisions required for maintenance throughout the lifetime of the System.
7. Contractor shall supply all Special Tools, Equipment, tools, and provisions as specified in Section 21.

30.5 RAM MANAGEMENT AND DELIVERY

30.5.1 RAM PLAN

1. Contractor shall submit the following details, as a minimum, in an EN50126: 2017 compliant RAM Plan [CDRL]:
    a. Required methodology to verify RAM requirements are incorporated into the final design.
    b. Deliverables, Phasing, Co-ordination, and Scheduling.
    c. Planned Analysis and Predictions including Apportionment of RAM targets to subsystems and components
    d. Use and Control of the CBTC System’s Architecture as the basis of all subsequent RAM and Safety analysis
    e. An organizational chart showing Contractor’s leadership, management, resources, and capability to achieve the quantified RAM Targets.

f. Linkage to Systems Integration, Engineering and Testing regimes. Where mitigation of RAM risks is by reference to test, Contractor shall identify the unique event in the base Failure Modes and Effects Analysis (FMEA)/Component Failure Effects Criticality Analysis (FMECA) specific to that risk within the test documentation.

g. RAM activities in compliance with Appendix I to the Agreement and Section 7 of EN50126: 2017, Part 1. and integrated in the Project Schedule with clear relationship to RAM Deliverables and related Milestones.

30.5.1.1 DESIGN FOR RELIABILITY

1. Starting in the Design Phase, Contractor shall develop, implement, and maintain a design methodology for ensuring the Reliability of the System (including software) throughout all Phases of the Project.

2. The processes Contractor applies to support the required Performance Metrics, as described in the RAM Plan, shall:

    a. Ensure that Reliability requirements are specified and verifiable from the start of the design development.

    b. Monitor and verify RAMS assumptions and requirements throughout the design period.

    c. Identify and eliminate all single point causes of failure.

    d. Analyze and develop Software and data, which are to be considered integral to the achievement of RAMS targets within the CBTC System. The Contractor shall employ methods for assessing and predicting the reliability of software, based on a life-cycle approach to software reliability engineering (SRE), are prescribed in IEEE 1633-2016 Recommended Practice on Software Reliability.

    e. Ensure that failure risks are mitigated by appropriate designs and procedures.

    f. Demonstrate (in the RAM Plan and throughout all design Deliverables) that the fullest participation of all internal parties and external Project stakeholders and Contractor's sub-contractors is planned to occur or has occurred.

    g. Demonstrate that Reliability requirements are included within the correct System, subsystem, and component according to the design. Contractor shall identify activities in the Project Schedule that indicate when these demonstrations occur.

3. As defined in Section 2.3, each of the Deployment Phases corresponds to a specific geographic area for the purposes of rolling out completed, tested, and ensured CBTC Equipment.

4. Each Deployment Phase shall comprise a separate V-lifecycle (per EN50126), with attendant RAM Deliverables, integrated test and validation regime, sub-system verification and RMDT (Reliability and Maintainability Demonstration Testing), as if each were a separate Project.

    a. Contractor shall include all previously demonstrated Deployment Phases in the RAM Demonstration for each untested Deployment Phase such that the full CBTC System is demonstrated at each Deployment Phase.

    b. Contractor shall submit an updated Reliability prediction for each Deployment Phase.

    c. Contractor shall use available data from the portions of the CBTC System that have been Commissioned to compare against Reliability targets for the demonstration testing.

d. Contractor shall thoroughly review elements in each Deployment Phase for differences in content or Configuration that may explain differences in the data.

30.5.2 REDUNDANCY

1. Contractor shall fully justify the need for Equipment redundancy and identify the requirement on the Systems Architecture.

2. Non-redundant Equipment shall have proven data to be sufficiently reliable to satisfy the overall System Availability requirements.

30.5.3 BUILT IN TEST EQUIPMENT, DIAGNOSTICS AND COMMUNICATIONS

1. Contractor shall supply Built in Test Equipment (BITE) and Diagnostic devices and/or algorithms to optimize Reliability, for example, using predictive algorithms, where necessary, to meet the System Availability objectives.

2. Contractor shall describe these Built in Test Equipment (BITE) and Diagnostic Devices within the AMS Design Description Document specified in Section 20.

3. Contractor shall minimize the total Maximum Preventive Maintenance Person-hours and Maximum Corrective Maintenance Person-hours by reducing diagnostic time or by optimizing Preventive Maintenance schedules. Contractor shall submit the expected Maximum Preventive Maintenance Person-hours and Maximum Corrective Maintenance Person-hour predictions on a quarterly basis throughout all Phases of the Project.

4. Contractor shall ensure that diagnostic test equipment (i.e., test bench) does not remove valuable information in the form of logs, stored state data or any other information related to the potential Root Cause of the failure. The Root Cause Analysis of faulty Line Replaceable Units (LRUs) shall use this data to develop the analysis.

30.5.4 RAM STANDARDS

1. Contractor shall design the CBTC System according to CENELEC EN 50126 – Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) shall apply throughout the term of the Contract and apply to all Phases of the Project and all elements of the Work.

30.6 RAM ANALYSIS AND VERIFICATION

30.6.1 LEVEL OF REPAIR ANALYSIS

1. Contractor shall conduct and submit for SFMTA approval, an Interim Level of Repair Analysis (LORA) [CDRL] to determine when item in the CBTC System will be replaced, repaired, or discarded based on cost considerations and operational readiness requirements. Contractor shall organise the LORA according to the List of Parts as an indented Bill of Material and shall submit possible repair decisions, to determine an optimal provision of repair and maintenance facilities to minimize overall life-cycle costs. Contractor shall itemise the LORA when submitted to SFMTA.

2. The LORA shall be submitted at both Preliminary and Final Design.

3. Contractor shall:

a. Ensure alignment with the Concept of Operations and Maintenance [CDRL] described in Section 3.2.2 of this Specification.

b. Quantify maintenance requirements for the System, based on the service

c. Perform Level of Repair Analysis (LORA) [CDRL] for all CBTC System Equipment.

4. Contractor shall submit both a LORA Proforma and Completed Example LORA [CDRL] to SFMTA for the purposes of evaluation and approval.

5. Contractor shall itemise both the LORA Proforma and Completed Example on the CDRL.

6. Contractor shall perform all analysis to the lowest quantifiable unit level or Line Replaceable Unit level. Contractor shall consider an LRU as a modular component of the System designed to be replaced in the identified repair or restoration time window at the operating location. Replacement of an LRU is an act of First Line Maintenance. Contractor shall submit a listing of all LRUs with the first delivery of the Reliability and Maintainability Prediction.

7. Contractor shall submit in-service, proven and verified data from previous Contractor Projects is preferred. Contractor shall submit such data in the first instance.

30.6.2 RELIABILITY AND MAINTAINABILITY PREDICTION

1. Maintainability Prediction is an analytical technique used to determine the effectiveness of repair and maintenance measures. The output from the prediction includes MTTR (Mean Time To Repair), MCMT (Mean Corrective Maintenance Time) and MPMT (Mean Preventive Maintenance Time).

2. Contractor shall develop, submit and maintain current the Maintainability Prediction throughout all stages of the CBTC System design and implementation.

3. Entries in the Maintainability Prediction shall trace to the System Architecture.

4. The Maintainability Prediction shall comply to the applicable Standards in Section 7 (Codes and Standards).

5. Contractor shall perform a Reliability Prediction using IEC 61709:2017, or equivalent.

a. Reliability Prediction may be based on a Parts Count method and be conducted in a Spreadsheet or by means of a verified and approved proprietary Software.

b. It shall separately identify component or part function.

c. Contractor shall maintain current the Reliability Prediction throughout all stages of the Project.

d. Contractor shall make all assumptions explicit in the analysis and published with the analysis. Sensitivity Analysis may be performed on Reliability Predictions to reveal the influence on key assumptions underpinning the conclusions of the Reliability Prediction.

6. Contractor shall include and publish a prediction of the required maintenance person-hours for the by line replaceable unit level as part of the RAM Prediction Analysis Report [CDRL] described in Section 4.

a. The RAM Prediction Analysis Report shall detail the number of hours preventative and corrective maintenance that the System will be require in any given year.

b. Contractor shall state all assumptions in the course of producing this prediction.

7. Contractor shall submit an Initial Reliability, Availability and Maintainability Prediction analysis report [CDRL] at the Preliminary Design Review that includes all spares, components, Equipment, sub-systems, and systems with the CBTC System.

8. The RAM Prediction Analysis shall confirm Contractor's understanding of and commitment to the Performance Targets specified in Appendix I to the Agreement.

9. Contractor shall submit examples that are traceable to published basic data sources and references to substantiate its RAM Prediction Analysis .

10. Contractor shall update the Reliability, Availability and Maintainability Prediction analysis report monthly using the Train Control System Upload Template from Appendix J to the Agreement, and include in Contractor's Progress Report.

11. Contractor shall use a recognized methodology, including Fault Tree Assessment and / or RBD to lowest quantifiable component (or LRU) level at or before deployment of any Software release.

30.6.3 PROVISIONAL RAM APPORTIONMENT.

1. Contractor shall allocate individual quantitative targets to each of the various subsystems or components defined in the CBTC System Architecture.

2. Contractor shall maintain current the RAM Apportionment [CDRL] and update as necessary through the design development and the successful conclusion of the RMDT.

3. Contractor shall describe a well-specified process that correctly allocates targets to functions and to systems, sub-systems, and components such that the Reliability, Availability, and Maintainability targets can be achieved or exceeded.

4. Contractor shall account for environmental and operating conditions, considering the correct Equipment population, operating point, maintenance and maintainability requirements and environmental conditions.

30.6.4 DETAILED ANALYSIS

1. At each Preliminary Design, Final Design Construction Final Design, and beginning of any RAM Demonstration, Contractor shall submit the following analyses to substantiate the predicted Reliability of the System:

    a. Functional Failure Modes and Effects Analysis (FMEA) to IEC61802 [CDRL],

    b. Component Failure Modes Effects and Criticality Analysis (FMECA) to IEC61802 [CDRL],

    c. Fault Tree Analyses and/or Reliability Block Diagram (RBD) to IEC61025 [CDRL].

    d. Level of Repair Analysis (LORA) to SAE AS1390 [CDRL].

    e. Maintenance Assessments to predict the number of preventative and corrective maintenance person-hours for the System to IEC25000 [CDRL]

    f. Software Reliability Analysis [CDRL] and others as identified in the CDRL to IEC12207 and IEEE 1633-2016.

    g. Software Reliability Program Plan (SRPP) to IEEE 1633-2016 as part of CDRL 30.01 RAM Plan.

2. Contractor shall demonstrate how the System components used in the RAM Analysis can be traced to the Systems Architecture described in Section 4.

3. Contractor shall include analysis of systemic and random failures as contributors to the achievement of Reliability and maintainability targets.

    a. Systemic failures are specified as those failures related in a deterministic way to a certain cause, that can only be eliminated by a change in the design or, in the manufacturing process, operational procedures, documentation or other relevant factors.

    b. Random failures are specified as those failures that may occur unpredictably during the lifetime of a System element, and that follows a given probability distribution.

4. All Safety Critical Items identified and described in the Hazard Log that occur during the RMDT period or during Revenue Service shall have the event highlighted in the Reliability and Maintainability Predictions and in the subsequent detailed analyses (including FMECA/FMEA, RBD) produced for the Reliability predictions.

5. Contractor shall highlight and substantiate the Reliability of Safety Critical Items [CDRL] in the published Reliability predictions.

6. Contractor shall include assessments of Common-mode and Common-cause failures for those events and/or Equipment that use or depend on redundancy.

7. All predictions and analyses shall contain a comprehensive account and consideration of the causes and effects of Common Mode Failures (CMF) and Common Cause Failures (CCF). No beta factor shall exceed 90%.

8. Contractor shall state how redundancy is to be achieved and reflect this understanding both in the Systems Architecture and in the RBD/Fault Tree Analysis modelling of the System to be provided.

30.6.5 RAM VERIFICATION – RELIABILITY, AVAILABILITY AND MAINTAINABILITY DEMONSTRATION TESTING

1. Contractor shall perform Reliability and Maintainability Demonstration Testing (RMDT) for a minimum of 6 (six) months during the two RAM Demonstrations.

2. The success criteria of the RMDT shall prove through demonstration each of the Performance Requirements outlined in Table 30.1 using Standard IEC 60300-3-5 (2001-03).

3. Contractor shall demonstrate targets to be attained using an approved RMDT technique, as selected from this Standard.

4. Contractor shall submit the RMDT Plan [CDRL] and performance criteria at the Final Design Review.

5. Contractor shall submit the RMDT Procedures [CDRL] and agreed by SFMTA six (6) months prior to the Initial RAM Demonstration.

6. Contractor shall classify failures during the RMDT as Chargeable or Non-Chargeable.

7. Contractor shall use the impacts created by chargeable failures, including software failures, in the various calculations and metrics required to report performance details.

8. Impacts caused by Non-Chargeable failures shall not be used in the various calculations and metrics required to report performance details.

9. Contractor shall include a list of Chargeable failures in the RMDT Plan for SFMTA review and approval.

10. Chargeable failures shall include, but are not limited to, the following:

    a. Failures that occur at irregular intervals.

    b. Unverified or verified failures

        i. Failures which cannot be duplicated on site or during first- or second-line maintenance, which are still under investigation, or for which no cause could be determined, signified as 'No Fault Found' or NFF

    c. Independent failures caused by:

        i. Equipment design or manufacturing.

        ii. Part or sub-system design or manufacture (whether directly or indirectly supplied by Contractor or their Suppliers).

        iii. Software Bugs as defined in Section 1.4.1 or data Configuration errors.

        iv. Operating, maintenance, or repair procedures that cause Equipment failures.

    d. All Significant Failures

11. Contractor shall track all failures found during any RMDT period through Contractor FRACAS.

12. Failure of any portion of the RMDT requires Contractor to end the RAM Demonstration and restart it, in accordance with procedures specified in Section 8.3.3 (RAM Demonstration).

13. Software Bugs or data Configuration errors identified, corrected, and verified during the software pretest, system verification, and system test shall not be regarded as a chargeable failure.

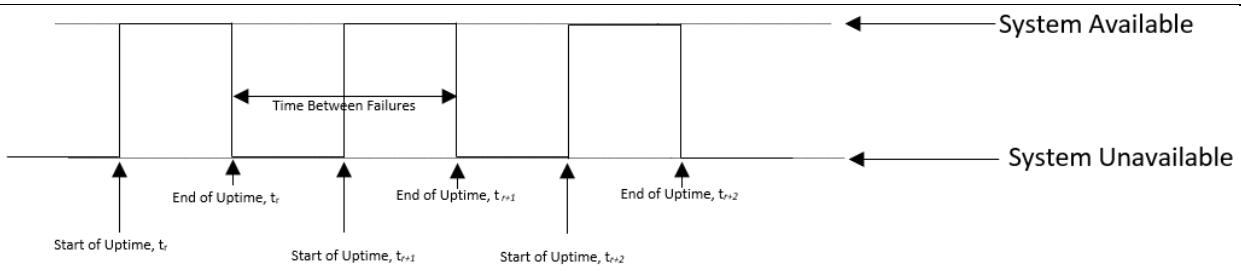
30.7 RAM FORMULAE

30.7.1 DEFINITIONS

1. Refer to Figure 30-2. Contractor shall use the parameters of 'uptime', 'Downtime' and Availability when these periods commence and cease.

2. Contractor shall note that '*r*' is an index variable, which represents the times of failure or corrective action in the following manner: t_1, t_2, t_3, ….., t_{r-3}, t_{r-2}, t_{r-1},….,t_n.

Figure 30-2: Definitions of the Commencement of Uptime, Downtime and Availability.



n_f = total number of failures
n_c = total number of corrective actions
t_r = time at which failure or corrective action occurs

30.7.2 SYSTEM RELIABILITY MEASURES

1. Contractor shall use the following calculations when developing Reliability and Availability target and RMDT metrics:

   a. Mean Downtime (MDT):

$$MDT = \frac{\sum_{r=1}^{n_f}(start\ of\ uptime,\ t_{r+1} - end\ of\ uptime, t_r)}{Total\ number\ of\ failures,\ n_f}$$

   b. Mean Uptime (MUT):

$$MUT = \frac{\sum_{r=1}^{n_f}(end\ of\ uptime, t_r - \ start\ of\ uptime, t_r)}{Total\ number\ of\ failures,\ n_f}$$

   c. Mean Time Between Failures (MTBF):

$$MTBF = \frac{\sum_{r=1}^{n_f}(end\ of\ uptime, t_{r+1} - \ end\ of\ uptime, t_r)}{Total\ number\ of\ failures,\ n_f}$$

$Failure\ Rate\ (FIT), \lambda = \frac{10^9}{MTBF}$, where 10^9 is a dimensionless factor of one thousand million.

   d. System Maintainability:

$$MTTR = \frac{\sum_{r=1}^{n_c}(end\ of\ corrective\ action\ time, t_r - start\ of\ corrective\ action\ time, t_r}{Total\ number\ of\ Corrective\ Actions, n_c}$$

   e. System Availability:

$$System\ Availability\ (A_s) = \frac{MTBF}{(MTBF + MTTR)}$$

2. Contractor shall specify any additional RAM Formulae to be used in its preliminary RAM Plan.

30.8 RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM) CDRLS

Table 30-3: RAM CDRL Table

CDRL #	CDRL Title
30.01	Reliability, Availability, and Maintainability (RAM) Plan
30.02	Level of Repair Analysis (LORA)
30.03	RAM Prediction Analysis Report
30.04	RAM Apportionment
30.05	Functional Failure Modes and Effect Analysis (FMEA)
30.06	Component Failure Modes Effects and Criticality Analysis (FMECA)
30.07	Fault Tree Analysis Diagram
30.08	Fault Tree Analysis
30.09	Maintenance Assessment for Preventive and Corrective Maintenance
30.10	Software Reliability Analysis
30.11	Reliability Block Diagram (RBD)
30.12	RAM Demonstration Testing Plan
30.13	RMDT Procedures
30.14	Interim RMDT Plan and Procedure
30.15	Reliability of Safety Critical Items List
30.16	RMDT Report

31 TESTING AND COMMISSIONING

31.1 PURPOSE

1. This Section contains the requirements for the inspection, test and Commissioning activities that support the verification and validation of the System. This Section should be considered minimum requirements. Contractor shall define and carry out additional testing, verification or validation, as needed to comply with the Contract requirements and certification.

31.2 GENERAL

1. Contractor shall perform all testing for which Contractor has provided test procedures as described in Section 31.4.2 (Test Procedures), except as explicitly stated in this Section 31.2.

2. Contractor shall provide a record of all completed tests to SFMTA.

3. SFMTA shall have the option to witness all tests and will review and approve test results.

4. Contractor shall plan and detail within the Project Schedule the execution of all testing and Commissioning activities required for the Project.

5. Contractor shall ensure that all tests are carried out in a manner that minimizes the impact on SFMTA operations and with no reduction in the safety of the transit system.

6. Contractor shall provide all plans, procedures, Equipment, Special Tools, simulations and Software, personnel, and preparation required to successfully perform the testing and Commissioning of the CBTC System.

7. Contractor's test plans shall describe any required SFMTA Furnished Items necessary to carry out the tests, such as access to trackways, tunnels and facilities, or SFMTA resources such as maintenance staff, Trains, Train Operators, Transportation Controllers. SFMTA Furnished Items are described in Section 9.

8. Contractor shall meet SFMTA's access requirements when planning and executing tests, including deadlines for requesting SFMTA Furnished Items, as specified in SFMTA Track and Tunnel Access Procedures included in Appendix J to the Agreement.

9. Contractor shall fully trace testing requirements to these Contract Specifications and design requirements. SFMTA will audit this traceability as it deems necessary.

10. Contractor shall maintain all test records and traceability under secured Configuration management for the duration of this Contract.

11. The objective of Contractor's test program shall include to "test for failure" as well as to "test for success".

12. It is not sufficient that Contractor adequately complete "test for success" procedures, where during the execution of each step of the test procedure, the results are verified against the expected results. Rather, Contractor shall examine functionality and operations which should not occur, and verify that these do not occur through test, simulation, or analysis as appropriate.

13. Contractor shall propose an approach for performing corrective action for SFMTA approval and retest if the initial test provides unsatisfactory results.

14. Contractor shall accommodate SFMTA personnel participating in or witnessing any testing performed by Contractor, its Subcontractors, or Affiliates.

15. Contractor shall facilitate SFMTA audits of Contractor internal testing, including Software unit testing.

31.3 INSPECTION

1. Contractor shall conduct regular inspections of the procurement, manufacturing, and testing processes in accordance with guidelines specified by the Quality Assurance Program Plan (QAPP) as described in Section 5 (Quality Assurance and Quality Control).

31.3.1 FIRST ARTICLE CONFIGURATION INSPECTION

1. The First Article Configuration Inspection (FACI) shall take place at the point of assembly after completion of factory acceptance and environmental qualification testing of first production Hardware.

2. Prior to the FACI, Contractor shall submit a written inspection procedure [CDRL] to SFMTA for approval at least 60 calendar Days before the FACI date.

3. Contractor shall not proceed with the FACI until the written inspection procedure has been approved.

4. Contractor shall notify SFMTA of the proposed FACI no less than 30 calendar Days before the FACI date. Subsequently, Contractor will be advised regarding SFMTA's attendance. SFMTA may attend FACI for all non-Commercial Off the Shelf (COTS) equipment.

5. The FACI shall verify that production Hardware complies with design Configuration, Drawings, and Software design.

6. Contractor shall make available the design qualification and factory acceptance testing procedures and results for inspection at the FACI. SFMTA may request a repeat of a portion of the type testing and/or the complete routine tests during the FACI.

7. Contractor shall not conduct the FACIs until the design Drawings of the article have been conditionally accepted or accepted.

8. If conditionally accepted Drawings are used, Contractor shall satisfy the conditions for approval at the FACI and represented by the inspection article.

9. Before each FACI, Contractor shall submit for approval documentation that includes the latest assembly, component and detail Drawings, test procedures, specifications, system simulation requirements, quality documentation, reference to supporting processes, Standards required for adequate checkout of the Equipment under inspection, and a list of Drawings.

10. Contractor shall submit the following as part of the FACI Drawing Package [CDRL]:

    a. The FACI agenda, which shall include:

        i. Schedule

        ii. Contractor's facility address

        iii. Contractor contact

        iv. Component list with latest Drawing status

v. All material & component certifications

vi. Contractor inspection plan and procedures

b. A complete set of approved or conditionally approved Drawings and Software documentation (with SFMTA comments) and pre-FACI results, if applicable, for the item to be inspected.

c. The LRU and lowest LRU list.

d. Completed Contractor inspection forms that control and document approval of in-process work

e. Completed Contractor final inspection reports

f. Completed test documents that reflect that the assembly has passed testing

g. Packaging and shipping method(s) of FACI production methods to installation site.

11. Contractor shall provide the inspection workspace within the necessary physical environment for inspection of piece part, subassembly, or final assembly including:

a. When appropriate, Contractor shall display the inspection article on a stand or table in a well-lit workspace with all necessary inspection tools, go/no-go gauges, plug gauges and handling aids.

b. Contractor shall supply correct tools and labor to take mechanical or electrical measurements.

c. All tools shall carry valid calibration stickers.

d. Contractor shall supply tools and labor for disassembly and removal of covers. SFMTA will consider participating in pre-FACIs for complex Equipment where Contractor would like a preliminary SFMTA feedback on the Equipment before the FACI is performed.

31.4 TEST PLANNING AND REPORTING

1. Contractor shall develop and follow a comprehensive testing program for the CBTC System and subsystems. Requirements for test planning and reporting are provided in this Section.

2. Testing shall be based on functional test scenarios based on conditions that can be reasonably be expected to exist during the System's lifetime.

3. The desired outcome for each scenario shall be stated and form the basis for the test success criteria.

31.4.1 MASTER TEST PLAN AND TEST PROGRAM PLANS

1. Contractor shall submit a Master Test Plan [CDRL] that details the overall test approach for the CBTC System.

2. The Master Test Plan shall comply with the Testing and Commissioning requirements specified in this Section to demonstrate CBTC System readiness for Revenue Service.

3. Contractor shall deliver a set of Test Program Plans [CDRL] that detail the process and the activities for all testing performed in factory and field.

4. The Test Program Plan shall include a listing of all levels of testing as specified by Contractor in the Master Test Plan approved by SFMTA.

5. The Test Program Plan shall comply with all applicable CPUC General Orders, see Section 7 (Codes and Standards)

6. The Test Program Plans shall include the following:

    a. Test sequencing, test duration and test location

    b. List of individual tests to be performed and the purpose of each test

    c. Responsibilities of Contractor and SFMTA personnel

    d. Record-keeping assignments, procedures, and forms

    e. Methodology for correcting variances

    f. List of all documentation to be used during the test

    g. A description of the set up, Equipment, simulators and data to be used for the tests

    h. Block diagram of the Hardware test Configuration and circuit diagrams

    i. Techniques and scenarios used to simulate ultimate system loading during performance tests

    j. Time allotted for informal testing

    k. Time allotted for SFMTA-directed testing

    l. Methodology for developing test procedures

31.4.2 TEST PROCEDURES

1. For each test activity described in this Section, Contractor shall submit a Test Procedure [CDRL] for SFMTA approval a minimum of 45 Days prior to the test activity.

2. Each Test Procedure shall contain, at a minimum, the following:

    a. Test objective with the name of the feature and/or function to be tested

    b. Revision level and reference number of the test procedure

    c. Name of the author of the Revision of the test procedure

    d. References to the functional, design, user, and any other documents describing the function

    e. A list of test cases and steps to be performed

    f. Descriptions of each test step, including Train movements and the inputs and user actions for each test step

    g. Expected results for each step (“test parameters”) with success/failure criteria in quantitative terms

    h. Tracing of requirements to each test case step

    i. Test location, associated affected area and affected subsystems and components of the SFMTA CBTC System

    j. Estimated duration of the test

    k. Safety issues and concerns to be addressed/mitigated

l. Required outages, schedule impacts, and recovery methods

m. Sequence of testing including prerequisite tests

n. Test setup and initial conditions, Equipment and instrumentation required

o. Descriptions of the techniques and scenarios to be used to simulate System field inputs and controlled Equipment

p. Resources and support required from SFMTA, including personnel, equipment, and Trains/work Vehicles

q. Data to be recorded and evaluation procedure

r. Reference to Problem/Failure Report generated as necessary

3. If Contractor has existing standard Test Procedures for its Base Product that differ from the format described in this Section, Contractor may submit the format to SFMTA for review. Contractor shall use the format described in this section unless SFMTA approves Contractor's format.

4. Contractor shall customize its generic test procedures to include site-specific details (such as "Pull out Test Train from Green division, pull Train onto West Portal Avenue via the K line"), including set-up steps to ensure all personnel and equipment are correctly situated at the start of the test.

5. For field testing, Test Procedures shall include a step-by-step process all Configurations for testing and post testing, including opening and closing of circuits.

6. For field testing, Test Procedures shall require verification of System Configurations before testing and after testing.

7. Test Procedures shall include pre-printed test data sheets and checklists for each test. Contractor may use electronic tablets instead of paper to meet this requirement.

8. When completed by the test personnel and checked for accuracy and completeness, Contractor shall submit the test data sheet as the test report.

9. The test data sheets shall include checklists for each test, and a blank space adjacent to the expected range of values in which to record the test readings.

10. When tests require specific test instrument readings, the test data sheet shall show the allowable range of values for each step of the test.

11. The test report shall include the instrument serial number and calibration information and the calibration expiration date.

12. When tests include observations that do not require instrument readings, each observation shall have its own check mark.

13. Contractor shall not use a single check mark for groups of tests.

14. During field testing, Contractor shall use red wire if any jumpers or special wiring are temporarily added for any reason.

    a. Contractor shall maintain a record on a log sheet indicating the circuit involved, the placement of the jumper or special wiring, the purpose for the change, and when jumpers or special wiring are added and removed.

b. Contractor shall number, record, and remove all jumpers and temporary wiring after the completion of the test, and the removal noted on the log sheet.

c. Contractor shall sign log sheet entries with a copy furnished to SFMTA.

31.4.3 OPEN ITEM DESCRIPTION

1. Upon the identification during testing of any failure or anomaly, Contractor shall prepare and submit an Open Item Description [CDRL] within 14 Days of the test, regardless if the failure or anomaly is due to CBTC System causes. A failure is a condition that causes testing to halt. An anomaly is any result outside the prescribed test parameters which may not have immediately halted the test.

2. Each Open Item Description shall include a complete description of the failure or anomaly, including:

    a. A sequential identifying number assigned to the Open Item

    b. The date and time the Open Item was detected

    c. References to the test procedures being executed when the Open Item was detected

    d. A description of the test conditions at the time the problem was detected and a methodology for reproducing the problem

    e. All Specification Requirements affected by or related to the Open Item

    f. Whether the Open Item impacts safety, operations, both, or neither. If the Open Item impacts either safety or operations, the Open Item Description must include a proposed mitigation plan for SFMTA approval

    g. Identification of Contractor's test personnel and SFMTA witnesses

    h. A description of the cause of the Open Item and corrective actions taken or to be completed as part of the Open Item resolution process.

    i. Status of the corrective action at the time the Open Item Description is submitted

    j. Space for future entry of the following information

        i. Follow-up actions

        ii. Correction date

        iii. Version of Software and/or Hardware where corrected

    k. A dated signature line for SFMTA and Contractor's representatives to certify correction of the Open Item

3. Contractor shall enter all Open Items into an approved tracking tool.

4. Contractor shall submit monthly problem summaries in the form of an updated Testing & Commissioning Open Item List [CDRL] that identifies each problem, the report number, a brief description of the problem, and its current status (open or resolved).

5. Contractor shall periodically review the Open Item List with SFMTA .

6. Contractor shall submit monthly metrics reports along with the Open Item List as specified in the Master Test Plan.

7. If an Open Item is identified during the factory testing, no Equipment related to the specific Open Item shall be shipped to the installation site. Contractor may request exemptions to this requirement, subject to SFMTA approval.

8. If an Open Item is identified during field testing, no Equipment related to the specific Open Item may be placed into service without a resolution. Contractor may request exemptions to this requirement, subject to SFMTA approval. Depending on the severity of the Open Item, SFMTA will direct the Contractor to either:

    a. Immediately stop testing and evaluate and correct the Open Item before testing is resumed; or

    b. Continue testing, and evaluate and correct the Open Item no later than a mutually agreed upon time.

9. Contractor shall update Open Item Descriptions to describe all actions taken to resolve the Open Item.

10. Contractor shall submit sufficient information to enable SFMTA to determine the need for and extent of re-testing, the impact of the correction on any previously tested Hardware or Software, the need for new additional testing, and the need for updating appropriate System documentation.

11. An Open Item Description status shall be considered resolved only when all re-testing has been performed to the satisfaction of SFMTA and after SFMTA acknowledges correction of the Open Item on the Open Item Description [CDRL].

12. Final Acceptance will not be given by SFMTA until all Open Items are resolved.

31.4.4 RETESTS

1. Contractor shall conduct a retest if the conduct, conditions, indications or results of a test differ from the procedures, conditions, indications or parameters in the approved test procedure.

2. Contractor shall propose retesting based on the nature and the impact of Open Item or any change or correction to the test results necessary for SFMTA approval.

3. Contractor shall perform additional testing at no cost to the SFMTA when required due to defects in design, Materials, or Contractor’s workmanship.

31.4.5 REGRESSION TESTING

1. Contractor shall perform a suite of regression tests in the factory and the field as appropriate on each modified Software release or Hardware item to ensure that no degradation of baseline functionality has occurred.

2. Contractor shall submit a Regression Test Procedure [CDRL] for each major CBTC subsystem.

31.4.6 SOFTWARE RELEASE DEMONSTRATIONS

1. Contractor shall perform two demonstrations of new or modified functionalities of any Software releases to SFMTA operations staff: once on the Supplier's premises prior to FAT, and once after FAT, on the SFMTA CBTC simulator at the backup Control Center. Each demonstration must confirm that the Software product delivered meets the requirements set out for the release and SFMTA operational needs. Contractor shall modify the proposed Software release based on feedback received during these demonstrations.

2. Following the second demonstration (or any modifications to the proposed Software release based on SFMTA feedback from the second demonstration) but before the new Software release is deployed to the revenue system, Contractor shall install the proposed Software release on the SFMTA CBTC simulator at the backup Control Center for a familiarization period of one week. SFMTA will cycle operations staff through the simulator as needed to familiarize them with the modified or new features.

3. Contractor shall submit a New Release Operations Test Procedure [CDRL], which demonstrates the new or modified features to SFMTA personnel, at the beginning of the familiarization period.

31.4.7 TEST REPORTS

1. Upon completion of each type of test described in this Section, Contractor shall submit a test report [CDRL] to SFMTA for review and approval.

2. Test reports shall include, at a minimum, the following:

    a. Reference to the appropriate section of the test procedures

    b. Description of the test performed

    c. Date of the test

    d. Description of all problems encountered and applicable identification number

    e. Test results

    f. Identification by signature of Contractor's test engineer, and of SFMTA personnel or representatives present (if any)

    g. Provision for comments by SFMTA representatives

    h. Names of any log files used to verify results

    i. Any deviations to the test procedure

    j. Retest procedures, if required

    k. Software/Hardware revision number

3. Contractor shall submit these reports for SFMTA approval in 15 calendar Days after completion of the tests.

31.4.8 TEST NOTIFICATION AND REQUIREMENTS

1. Contractor shall request SFMTA approval for all tests (both on and off SFMTA site) to be performed.

2. Contractor shall submit all test procedures, Drawings, schematics, Standards, or other materials required for the test, including SFMTA Furnished Items (such as Trains or personnel), to SFMTA for review and approval a minimum of 45 days prior to the performance of the test.

3. Contractor shall address any changes to these documents required by SFMTA and resubmit to SFMTA for approval prior to the commencement of the test.

4. When requesting SFMTA approval for on-site tests requiring Contractor access to SFMTA tunnels, trackways, or Vehicles, Contractor shall meet SFMTA's Access requirements, including requirements

for advance notification for requesting SFMTA-furnished labor, equipment, and track access, as specified in SFMTA Track and Tunnel Access Procedures included in Appendix J to the Agreement.

5. In Contractor's request for approval of site testing requiring an access clearance, Contractor shall indicate the number of hours needed for the test, which days are required for testing, and which days are "buffer days" included for the purposes of retesting or to be used in the event testing proceeded more slowly than expected.

6. SFMTA operates an active railway. Contractor shall make every effort to minimize the number of test periods requiring an access clearance request.

7. Contractor shall be subject to Liquidated Damages, as provided for in section 5.18.9 of the Agreement, for causing excessive disruption to transit service or failing to follow SFMTA's procedures for obtaining track clearances.

8. Tests which affect portions of the CBTC System or other SFMTA technology systems that are in production or in Revenue Service shall receive prior approval by the Technology Change Advisory Board as specified in Section 15.3.

31.5 FACTORY TESTING

31.5.1 TYPE TESTS

1. Contractor shall complete Type Tests on all Equipment components to confirm that the Equipment is fit for its intended purpose in the environmental conditions specified in Section 27 and meets all other requirements of this Specification.

2. Contractor shall complete the Type Tests at Contractor's facility or other location acceptable to SFMTA.

3. Contractor shall successfully complete Type Tests only once for each Equipment component, except for Commercial-Of-The-Shelf (COTS) equipment for which Contractor may submit relevant manufacturer documentation in lieu of testing.

4. The Type Tests shall test, at a minimum, the following:

    a. Mechanical construction

    b. Shock and vibration, and impact resistance

    c. Temperature and humidity (environmental)

    d. Electromagnetic compatibility test

    e. Accelerated life test

5. Contractor shall submit the Type Tests results [CDRL] to SFMTA before the FACI.

6. Since the combined aggressive effects of tests may cause undue environmental stress on electronic CBTC Equipment, Contractor shall deliver the Equipment used in these tests to SFMTA, but not for the purpose of being used in Revenue Service. However, they can be refurbished and used as training aids. Contractor may request to keep those units for other purposes, subject to SFMTA approval.

7. Contractor shall develop a Functional Block Diagram [CDRL] that illustrates the individual components of the CBTC System which require Type Tests.

8. Utilizing the Type Test list derived from the functional block diagram, Contractor shall develop and submit Type Test Procedures [CDRL] to SFMTA for approval.

9. For all Equipment, Contractor shall submit manufacturer's descriptive literature, product specifications, published details, parts list, description, operations and maintenance manuals, performance/capacity rating schedules or charts, installation and, programming manuals and instructions.

10. If the CBTC component or subsystem in question is considered by SFMTA to be substantially identical in design to the Equipment previously deployed in other transit applications, Type Tests, in part or as a whole, may not be required. To waive this requirement, Contractor shall submit a request for waiver and provide the following data:

    a. A list of locations of current Equipment installations, with the duration of Revenue Service at each location

    b. A description of all relevant differences between the requirements at other installations and the requirements of this specification

    c. Safety analysis as applicable

    d. Test results of any relevant Type Tests that have been conducted on the Equipment previously

    e. Product certifications and documentation of tests performed for product certification

11. Based upon the submitted data, SFMTA will determine if the requirements for Type Tests may be waived. SFMTA shall consider specific requirements for each piece of Equipment individually, and certain tests may be waived while others may still be required.

31.5.2 ROUTINE TESTS

1. Contractor shall complete all routine tests on all production versions of each Equipment type except for Commercial-Of-The-Shelf (COTS) equipment for which Contractor may submit available manufacturer documentation in lieu of testing.

2. Contractor shall perform the routine tests that demonstrates proper operation of the Equipment.

3. Contractor shall complete the routine tests at Contractor’s facility or other location acceptable to SFMTA.

4. Contractor shall perform routine tests on all Hardware prior to the Equipment being sent to the field for installation.

5. At a minimum, Contractor shall perform the following routine tests to verify the design integrity of the CBTC System Hardware:

    a. Wiring continuity test

    b. Circuit breakdown test

    c. Functional test

31.5.3 FACTORY FUNCTIONAL TESTS

31.5.3.1 CBTC SYSTEM EQUIPMENT TESTS

1. Contractor shall assemble a representative set of CBTC System Equipment both at Contractor's engineering facility and at SFMTA's facilities. Both locations will be used to support Contractor CBTC System development and testing and the Factory Acceptance Tests. Based on the Phase of the Project Phase and the type of activity, Contractor and SFMTA will agree on the optimal location.

31.5.3.2 FACTORY ENGINEERING TESTS

1. Prior to performing Factory Acceptance Tests (FAT), Contractor shall perform factory engineering tests as a dry-run of the FAT to ensure that the CBTC System and components are well integrated and in complete, reliable working order.

31.5.3.3 FACTORY ACCEPTANCE TESTS

1. The FAT shall demonstrate that each CBTC subsystem meets their functional specifications.

2. The FAT shall combine all subsystems to demonstrate that the requirements of this specification are met. Contractor shall test only Deliverable Hardware and Software.

3. The FAT shall demonstrate the correct operation of the CBTC System working together with all other systems with which it interfaces. Where necessary, simulators may substitute for the actual systems for the purposes of demonstrating the interfaces.

4. Contractor shall not deliver any final Equipment or Software to SFMTA site until Contractor has demonstrated that the Equipment or Software conforms to the functional specifications by successfully carrying out the FAT.

5. Contractor shall develop and submit Factory Acceptance Test Procedures [CDRL] to SFMTA for approval.

6. Contractor shall perform a complete regeneration of the CBTC subsystem Software under test in the target environment, immediately prior to the start of FAT.

7. Contractor shall perform the FAT with assemblies powered and connected to devices that duplicate the input and output conditions during normal Revenue Service conditions.

8. Contractor shall perform testing for processors with a Configuration of Software that has been approved by SFMTA.

9. Contractor shall monitor continuously all outputs of CBTC System Equipment assemblies for anomalous operation.

10. Contractor shall have all instrument housings and cases wired complete at the point of assembly, with all Equipment installed in place.

11. All CBTC System Equipment inspection at the FAT site shall use up-to-date accepted production Drawings produced by Contractor.

12. Contractor shall submit the dry-run test records and written certification of completion of dry-run testing, to SFMTA for information at least one week prior to the start of FAT.

13. Successful completion of dry-run or other testing before FAT shall not relieve Contractor of any responsibilities of FAT.

31.6 TEST TRACKS

1. Contractor shall design and Furnish a test track in both the Green and MME rail yards.

2. Contractor shall provide all the necessary Equipment to allow for static and dynamic tests of the CBTC On-Board Equipment on the test tracks.

3. Contractor shall provide all the Equipment necessary to allow for CBTC fault finding, maintenance, and repairs.

4. Contractor shall Equip the test tracks to allow static tests of the CBTC On-Board Equipment.

5. Contractor shall plan and communicate to SFMTA the test track schedule and the resources needed from SFMTA, in compliance with SFMTA Track and Tunnel Access Procedures included in Appendix J to the Agreement.

6. The Test Tracks shall facilitate LRV operations in ATO, as described in Section 22.3 (Normal Operating Modes and Territories).

31.7 FIELD TESTING

1. This Section outlines the CBTC System field tests and requirements to be performed on SFMTA property. Contractor shall develop and submit and execute the necessary field test procedures to fully verify those functional, operational and Performance Requirements that cannot be tested in a FAT environment.

2. Contractor shall successfully complete FAT procedures before installing a Software and / or Hardware baseline in the field for field test.

3. Contractor shall submit a Software Version Description (SVD) [CDRL] document for each release of Software for installation at SFMTA site.

4. Contractor shall submit the SVD at the same time that the Software is released to SFMTA.

5. Contractor shall develop the SVD in accordance with IEEE Standard 1558, Procurement Type 5.

6. Each SVD shall include a description of the problems addressed or features added, changes to Software requirements, changes to the Software design, source code changes, a record of review results for each pertinent document, test plan changes, and test results.

7. Contractor shall also include the CRC value or equivalent information, which can be used to confirm the integrity of the Software loaded in the target.

8. The SVD shall summarize all Software Change Reports associated with the new version of Software and shall describe all installation instructions.

9. Contractor shall submit the SVD to SFMTA, for all Software releases, upon the start of Factory Acceptance Testing through Project completion.

31.7.1 CUTOVER

1. To allow field testing of the CBTC System in Revenue Service, Contractor shall devise methods to switch the System over and back allowing for rapid and safe changeovers from the existing signaling and ATCS to the CBTC System, and back to the existing signaling and ATCS.

2. The Contractor shall implement cutover methods that includes wayside, onboard, CBTC System Hardware and/or Software changeovers, where needed, to support Contractor's testing and Migration programs.

3. The switch over and back methods shall be easily accomplished at the beginning and end of a typical test work shift, without disturbing wiring or other existing equipment, or requiring other actions that could introduce errors or compromise the installation Safety Certification of the existing systems.

4. The Cutover methods shall be assessed by Contractor's safety department and verified with Post Installation Check Outs (PICOs).

5. All cutover method safety assessments and PICO documentation shall be defined in the Cutover Plan.

6. Contractor shall submit the Cutover Plan [CDRL] and Cutover Detailed Design as part of the System Design Documents.

31.7.2 POST INSTALLATION CHECK OUT TESTING

1. Contractor shall submit Post Installation Check Out (PICO) procedures [CDRL].

2. PICO tests shall verify that the on-site assembly and installation has been carried out according to the design and Installation Specifications.

3. Wayside PICO tests for which Contractor has submitted test procedures shall be performed or witnessed by the Contractor.

4. Vehicle PICO tests for which Contractor has submitted test procedures shall be performed by the Contractor.

5. Contractor shall sign off on all PICO tests indicating it has performed or witnessed the test being conducted in accordance with the accepted procedures.

6. For each Deployment Phase and Vehicle, Contractor shall inspect the installation of CBTC Equipment and review the Equipment PICO tests to verify that the on-site assembly and installation has been carried out according to the design and Installation Specifications.

7. At the conclusion of PICO testing of each item of Equipment and each Vehicle, Contractor shall:

    a. Submit a written statement to SFMTA [CDRL] that the Equipment was installed in accordance with Contractor's specifications, or

    b. Submit a punch list as provided in Section 8.5.1 (Contractor's Responsibilities With Respect to Installation).

8. Contractor may conduct any additional tests or observations to assess if correction, re-check, and re-test will be necessary prior to submitting the PICO Test Reports and Installation Verification to SFMTA. SFMTA shall approve any additional tests or observations prior to execution.

9. Subsequent field-testing activities of any subsystem shall not proceed until the relevant PICO tests are completed.

31.7.3 SITE ENGINEERING TESTING

1. Contractor shall develop and submit Site Engineering Test Procedures [CDRL] to SFMTA for approval.

2. Contractor shall perform Site Engineering Testing after FAT and as a dry run of the Site Acceptance Tests.

3. With Site Engineering Testing, Contractor shall ensure that the CBTC System and components are well integrated and in complete, reliable working order, to allow higher level functional testing to proceed.

4. Contractor shall make any adjustments to the System or components needed for Site Acceptance Testing during Site Engineering Testing.

31.7.4 VEHICLE ACCEPTANCE TESTING

1. Contractor shall develop and execute a comprehensive Vehicle Test and Acceptance Plan [CDRL] and produce Vehicle Test Procedures and Test Reports [CDRL] for all CBTC onboard Equipment, including Equipment installed on Heritage and Maintenance Vehicles.

2. The Vehicle Test Procedures and Test Reports shall include Post Installation Check-Out (PICO), static, dynamic and System integration tests on all Vehicles.

3. The Vehicle Test and Acceptance Plan [CDRL] shall describe the test and acceptance process to be followed after installation of onboard CBTC Equipment.

4. As a minimum, the Vehicle Test and Acceptance Plan [CDRL] shall include:

    a. Static (Vehicle stationary) post installation check out (PICO) tests

    b. Dynamic (tests involving Vehicle movement) PICO functional tests

    c. On-Track Type Tests for each Vehicle type

5. Static PICO shall include:

    a. After the onboard Equipment is installed, complete installation check-out of onboard equipment

        i. Proper installation of onboard Equipment including mounting specifications.

        ii. Verification that completed assemblies have been correctly interconnected.

        iii. Conformance of Equipment wiring, cabling and grounding to cable plans, electrical codes and standards of workmanship.

    b. Inspection/ test of all installed Equipment necessary to commence dynamic, integration and functional testing.

    c. Interfaces and Configurations shall be checked out to verify the approved CBTC onboard and Vehicle ICD [CDRL] and CBTC onboard Design Descriptions {CDRL].

6. After the Static PICO is completed, a series of dynamic PICO tests shall be conducted to verify basic Vehicle functions.

7. Dynamic PICO shall test at least the following:

    a. Communication between wayside Equipment and the Vehicle.

    b. Onboard Equipment and Vehicle interface including, but not limited to, propulsion, brakes, emergency brake system, and car controls.

    c. Speed, position, and dynamic position uncertainty reporting.

    d. Train Operator Displays (TOD).

    e. Cut over capabilities between CBTC and the existing ATCS.

    f. Verification that the existing ATCS equipment continues to operate properly.

8. The Vehicle Test and Acceptance Plan shall also include Vehicle Readiness Tests to verify basic Vehicle functions, performance and interfaces between the Vehicle and other subsystems.

9. Vehicle Readiness Tests shall test at least the following:

    a. Operation without CBTC (Manual Mode). This is to confirm that the Vehicle operations on areas with no CBTC has not been impacted by the installation of the onboard CBTC Equipment.

    b. Verification of any redundant failover systems.

    c. Vehicle Testing in CBTC Territory to verify all specified System functionality is present.

10. Contractor shall submit Vehicle Acceptance Test Reports for SFMTA approval that document and verify that all Equipment has been installed, interconnected, configured, and successfully passed the tests prior to Vehicle acceptance.

31.7.5 SITE ACCEPTANCE TESTING

1. Contractor shall develop and submit Site Acceptance Test Procedures [CDRL] to SFMTA for approval.

2. Contractor shall not proceed with Site Acceptance Testing until FAT and Site Engineering Testing are completed with satisfactory results, subject to SFMTA approval.

3. Contractor shall not proceed with the subsequent Site Acceptance Testing until all defects from FAT and Site Engineering Testing are corrected or agreed to be corrected later by SFMTA.

4. Contractor shall perform Site Acceptance Testing on each Migration area of installation/cutover to demonstrate that the CBTC System satisfies performance, safety and functional requirements in SFMTA Operating Environment.

5. Site Acceptance Testing shall demonstrate full compatibility between all interfacing systems.

6. Contractor shall perform Site Acceptance Testing with Test Train(s) and demonstrate the capability of the System to operate Trains in all CBTC Territory in all Modes of Operation.

7. If simulated passenger loads are needed for any test, Contractor shall submit the loads that may be necessary. The Vehicle Installer will be responsible for the fitting and securing of the loads.

8. Contractor shall ensure that the loads are fixed in the Vehicle and that there is no risk of injury to site personnel and/or damage to railway property, from falling or shifting loads or any other Hazards.

9. At any time, SFMTA reserves the right to halt or curtail field testing based on overall CBTC System readiness, the number and severity of defects discovered, and the remaining unresolved defects, regardless of the categorization of the failure(s).

31.7.6 SHADOW MODE TESTING

1. Shadow Mode testing tests the new CBTC System before the existing ATCS is decommissioned, without the existing ATCS being cut-out. In the subways, the legacy ATCS will control the Train while the CBTC System shall stay disconnected from brakes, propulsions, switches, signals, and any other controls of the Vehicle and from any other parts of the wayside system.

2. Contractor shall perform Shadow Mode Testing with the CBTC System in a passive mode but powered, with inputs connected, to collect data for analysis.

3. This data collection shall be designed to take place during Revenue Service and during the operating day with revenue passengers on board Trains.

4. As part of the Shadow Mode Test Plan [CDRL] and Test Procedures [CDRL], Contractor shall list any tests and verifications that can be accomplished using Shadow Mode, for example, train localization and radio coverage, RAM, diagnostic data.

5. Prior to conducting Shadow Mode Testing, Contractor shall demonstrate the safety of Shadow Mode Testing outside of Revenue Service hours.

6. Contractor shall demonstrate that the CBTC System cannot interfere with or control Trains in Revenue Service when placed in Shadow Mode.

7. Contractor's test plans and procedures shall maximize the use of Shadow Mode Testing as an opportunity to reduce the risk of failures in the latter stages of testing.

31.7.7 PROCEDURE VERIFICATION TESTS

1. Contractor shall verify the validity and completeness of all CBTC System operating procedures, in normal and failure Modes of Operation.

2. Contractor shall perform Procedure Verification Tests [CDRL] for the following procedures:

    a. Operation

    b. System recovery

    c. Train recovery

    d. Scheduling

e. Special moves

f. CBTC System shutdown, start up, and operating sequences

g. Failure recovery

h. Emergency

i. Repair procedures

j. Control Center switchover from primary to backup, and vice-versa

k. Transfer of control from Control Center to Interlocking Local Control Panel, and vice-versa

l. Establishment and removal of Work Zones, track blocking, speed restrictions and similar items

31.7.8 SYSTEM STRESS TESTS

1. Contractor shall perform system stress tests on the entire System prior to CBTC Revenue Service. The objective of the test is to stress the CBTC System and demonstrate the System ability to operate under maximum loads and in the presence of failure mode conditions.

2. The stress tests shall include:

   a. Headway Operation

   b. Bunching

   c. Junction Management

   d. Maximum capacity of a zone controller and the communications subsystem including radio cells

   e. Equipment failures including loss of Train communication, zone controllers, On Board System, Interlockings

   f. Total loss of the ATS

   g. Other SFMTA-directed tests

3. Contractor shall submit the System Stress Tests Procedures [CDRL] to SFMTA for approval.

4. Contractor shall consider constraints such as available traction power that will be agreed upon by Contractor and SFMTA during the planning of the System Stress Tests.

31.7.9 REQUIRED CONTRACTOR SUPPORT FOR CBTC FIELD TESTING ACTIVITIES

1. Contractor shall make available all staging Equipment and material during pre-cutover testing to facilitate installation and testing activities, and replace defective Equipment as required.

2. Contractor's CBTC personnel shall attend at the cutover control point conducting the cutover.

3. Contractor shall:

    a. Provide manpower to each location involved in the cutover as required to adequately complete all required testing, and to make adjustments, changes, or corrections to successfully complete the testing.

    b. Provide enough personnel to provide replacement personnel on a 12-hour shift basis for the entire cutover, including weekends, for the duration of the cutover. This also applies to the CBTC Site Engineer, Test and Commissioning Manager, and Hardware and Software engineer(s), as required.

    c. Have personnel mobilized not less than one hour prior to the scheduled start of the cutover.

    d. Brief personnel supporting test activities before every test shift. The briefing shall include objective of the test, limits of the test, precautions to be taken.

31.8 SFMTA-DIRECTED TESTING

1. Contractor shall plan periods of SFMTA-directed testing as part of the Master Test Plan to allow SFMTA to verify proper operation of the CBTC System under the use cases specified in the Concept of Operation and Maintenance document and other use cases SFMTA may want to consider.

2. Contractor shall account for the following assumptions in the Master Test Plan and Project Schedule:

    a. A minimum of 1 week (40 hours) reserved at the end of each FAT iteration in each Deployment Phase for SFMTA-directed testing.

    b. A minimum of 20 working days reserved at the end of each site System Acceptance Test iteration in each Deployment Phase for SFMTA-directed site testing

3. SFMTA personnel shall perform SFMTA-directed testing at SFMTA discretion.

4. SFMTA-directed testing shall be a necessary condition for SFMTA Acceptance prior to Revenue Service of each Deployment Phase.

5. Any time required to correct CBTC System errors or faults found during SFMTA-directed tests shall not be considered an Unavoidable Delay.

6. Contractor shall comply with the following requirements with respect to SFMTA-directed testing:

    a. Contractor’s test representative shall attend SFMTA-directed test periods.

    b. Contractor shall make other technical staff members with relevant experience available for consultation with SFMTA during SFMTA-directed test periods.

31.9 RELIABILITY, AVAILABILITY, MAINTAINABILITY DEMONSTRATION TEST

1. Requirements are contained in Section 30.

31.10 TESTING AND COMMISSIONING CDRLS

Table 31-31: Testing and Commissioning CDRL Table

CDRL #	CDRL Title
31.01	First Article Configuration Inspection (FACI) Procedure
31.02	First Article Configuration Inspection (FACI) Drawing Package
31.03	Master Test Plan
31.04	Test Program Plans
31.05	Test and Regression Test Procedures
31.06	Testing and Commissioning Open Item List and Descriptions
31.07	Post New Release Test Procedure
31.08	Test Reports
31.09	Type test Functional Block Diagram
31.10	Type Test Procedures and Results
31.11	FAT Test Procedure
31.12	Software Version Description
31.13	Cutover plan
31.14	Post Installation Check Out (PICO) Procedures
31.15	Installation Verification
31.16	Site Engineering Test Procedures
31.17	Vehicle Acceptance Test Procedure
31.18	Site Acceptance Test Procedure
31.19	Shadow Mode Test Plan
31.20	Shadow Mode Test Procedures
31.21	Procedure Verification Tests
31.22	System Stress Test Procedures

32 SUPPORT SERVICES

32.1 PURPOSE

1. Contractor shall support the CBTC System for the Term of this Agreement, maintaining the System's performance to meet the functional, Performance and RAM Requirements in compliance with all approved plans, procedures and CDRLs.

2. This Contract includes a phased Migration and acceptance plan. Support Services for the portion of the System delivered in each Deployment Phase shall begin eighteen months after the Commissioning corresponding to that Deployment Phase, with the exception of the Pilot Phase.

3. The start of Support Services shall correspond to the end of each Warranty Period such that there is no gap between Warranty Services and Support Services. Section 8 specifies these transition periods and the Milestones which correspond to the start of Support Services.

4. This Section outlines a partnership between SFMTA and Contractor to support and maintain the System, in which the SFMTA provides maintenance labor, and Contractor shall provide technical, engineering, operations and maintenance Support, training, regular Software releases, and spare parts, as described in this Section. Contractor effort will be inversely proportional to the achieved CBTC System RAM metrics and the high performance of the CBTC System is incentivized by means of the performance-based payment structure in the Contract.

5. In this partnership SFMTA's goals and objectives to maintain a highly reliable system for its riders and to expend minimal labor in doing so align with Contractor's incentives to achieve the System RAM targets at minimal cost. The success of this partnership will optimize both SFMTA and Contractor's investments.

32.2 SUPPORT MANAGEMENT PLAN

1. Contractor shall develop and submit a CBTC Support Management Plan (SMP) [CDRL] for SFMTA approval six months in advance of the start of the Pilot Operating Period.

2. This plan shall describe the specific activities that will support successful operation and maintenance and high RAM performance of the CBTC System including software reliability and obsolescence mitigation during operations as outlined in the SRPP.

3. The SMP shall specify

    a. All CDRLs and other Deliverables that will be applicable to the Support scope

    b. Activities, Configuration, Equipment and tools required for the Support Term.

    c. A process and a schedule showing how Contractor will manage training and Support activities required throughout the life cycle of the CBTC System.

    d. System normal operation and maintenance processes, procedures, roles and responsibilities.

    e. System failure response processes, procedures, role and responsibilities

    f. The Change Control Processes, as described in Section 15 shall apply to all changes during Revenue Service, including Software updates.

g. The level of Contractor Support and oversight required from Contractor to achieve a world class but affordable "In House" maintenance supported by a description of all assumptions, resource needs, and rationale.

h. SFMTA and Contractor's staffing plan required to achieve the Support scope, with respect to the phased transition to warranty and Support during the Migration as described in Section 8.

i. Procedures and processes, contact information, and shipping information required for SFMTA to obtain third level maintenance services from Contractor.

j. Contractor's processes and procedures for providing technical Support at the service levels defined in Appendix I.2. to the Agreement.

4. Support procedures shall include:

a. Instructions for obtaining Support Services and notifying Contractor of the need to replenish Spare Parts.

b. Forms, reports, shipping and receiving instructions

c. Procedures to support claims processing, payments, and reimbursements in accordance with Contract requirements

d. Other administrative details needed for SFMTA personnel to obtain Spare Parts and Support Services

32.3 PERFORMANCE MANAGEMENT

1. Contractor shall utilize the Failure Reporting and Corrective Action System (FRACAS) for collection and management of the Performance Metrics and for monitoring the resolution of the failures affecting the CBTC System as described in Section 30.2.2.

2. Contractor shall support the Failure Review Board (FRB) process described in Section 30.2.2.1.

3. Representatives from both SFMTA and Contractor on the FRB shall monitor and validate the CBTC System Performance Metrics and review Contractor's performance with respect to resolving Issues and failures.

32.3.1 PERFORMANCE MONITORING

1. The monitoring of the CBTC System Performance metrics shall begin at the start of the Initial RAM Demonstration and continue through the Contract Term.

2. Contractor shall produce and distribute metrics and analysis of the System Performance in support of payments, changes, and all other needs.

32.4 SUPPORT SERVICES SCOPE OF WORK

32.4.1 PROVISION OF EQUIPMENT AND SPARE PARTS

1. Contractor shall supply all CBTC System spare parts and consumables required for the ongoing operations and maintenance for the duration of the Support Services at no additional charge beyond the monthly Support Services fee.

2. Contractor shall support all Special Tools and diagnostic equipment delivered as part of this Contract, including providing maintenance and Software for all SLMDs, Special Tools, simulators, or other diagnostic tools for the duration of the Support Services at no additional charge beyond the monthly Support Services fee.

3. As part of the Warranty and the Support Services, Contractor shall replenish spare parts, Special Tools and Materials as they are consumed, such that the warranty and Support quantities specified in Section 13.3.1 are maintained at all times during the term of this Contract.

4. Contractor shall manage the spare parts inventory as part of the Warranty and the Support Services.

5. Contractor shall base spares quantity and turnover of components as specified in Section 13.3.1 (Spare Parts Quantities).

6. If SFMTA consumed spare parts, Special Tools or Materials that meet one of the definitions of Reimbursable Parts in this Section, Contractor shall replenish the Reimbursable Parts and Contractor shall be entitled to reimbursement from SFMTA for them.

7. With 30 Days of delivery, Contractor shall submit a claim for reimbursement of any parts which Contractor believes meets one of the definitions of Reimbursable Parts in this Section. Within 10 Days of receiving a reimbursement claim, the SFMTA Project Manager or designee will determine whether the parts in question are Reimbursable Parts. The Contractor may request that the Failure Review Board review the Project Manager's determination.

8. Contractor shall include any records, data, or narratives necessary to support Contractor's reimbursement claim.

9. Contractor shall invoice the SFMTA for Reimbursable Parts as provided in Appendix B, Section B2.2.3.4.

10. The following are Reimbursable Parts:

    a. Spare parts, Special Tools or Materials which were not handled or stored in accordance with Contractor's handling instructions;

    b. Spare parts, Special Tools or Materials which were damaged as a result of any SFMTA operational and maintenance practices or procedures which are not in accordance with Contractor's operating and maintenance instructions;

    c. Spare parts, Special Tools or Materials which were damaged as a result of acts inconsistent with the use and maintenance of the CBTC System required by Contractor’s operating and maintenance instructions.

    d. Spare parts, Special Tools or Materials which were damaged as a result of exposure to environmental, climatic or other conditions exceeding those for which those parts, tools or Materials have been designed, as described in the Contract specifications;

    e. Spare parts, Special Tools or Materials which have damage caused by a malfunction or defect of any third-party item, piece, part or equipment;

    f. Spare parts, Special Tools or Materials which were damaged as a result of deferred or delayed maintenance, inconsistent with the Preventive Maintenance intervals specified in Contractor’s written maintenance and repair instructions;

g. Spare parts, Special Tools or Materials which were damaged following continued use after SFMTA should have known that their further use posed a risk of material damage.

h. Spare parts, Special Tools or Materials which were consumed during the repair of installation defects discovered by Contractor and included on an installation punch list or during the repair of hidden installation defects which could not have been discovered by the tests described in Section 8.5.1 (Contractor's Responsibilities With Respect to Installation) that Contractor performed. Contractor shall submit punch lists, test documentation and evidence that Contractor performed the applicable tests with the request for reimbursement.

11. Contractor shall store the spare parts, tools and Materials provided under this Contract in accordance with the requirements in Section 13.4.2.

12. All spare parts, consumables, tools and Equipment provided to SFMTA under this Contract are the property of SFMTA. This includes any spare parts inventory which may be stored at Contractor's local warehouses. Contractor shall deliver all such property of SFMTA to SFMTA within 120 days of the termination of this Contract.

32.4.2 TECHNICAL SUPPORT

1. Contractor shall provide continuous, 24/7 technical Support for Issues at the service levels, response and resolution times described in Appendix I.2 (Service Levels for Technical Support Services) to the Agreement, using the procedures described therein, as part of the Support Services.

2. Contractor shall deploy System Support Specialist (SSS) staff to ensure high-quality Support Services to SFMTA.

3. The SSS shall assist maintenance personnel employed in the first and second levels of maintenance where requested and serve as a technical resource to SFMTA rail operations and engineering staff.

4. The SSS may be supplemented with remote experts as conditions warrant but Contractor shall have at least two locally-based full-time SSS personnel assigned to work on-site at SFMTA's premises throughout the Support Term.

5. Contractor shall bear all costs of travel of other expert staff to/from San Francisco as needed to fulfill its obligations under this Contract.

6. The Contractor does not need to schedule an SSS to be on-site 24/7, but an SSS shall be on-site between the hours of 5 am to 9 am and 4 pm to 7 pm on weekdays.

7. Contractor shall include the SSS on-site hours in the CBTC Support Management Plan.

8. Each SSS shall have a significant working knowledge of the installed System.

9. Each SSS shall have the technical qualifications and ability to conduct troubleshooting, Root Cause analysis, and to guide SFMTA to perform preventive and corrective Software maintenance.

10. The senior SSS shall be the main point of contact between Contractor and SFMTA. The SSS shall analyze, record and transmit failure logs, and identify and resolve issues in the field.

11. Contractor shall submit the resume and qualifications for the SSS personnel to the SFMTA for approval.

12. The SFMTA shall approve the SSS prior to the SSS performing any Work on this Contract.

13. Prior to System Acceptance, the Contractor may designate one or more of its deployment personnel who are already on-site to fulfill the SSS role in addition to their other project duties. The names, titles and contact information for these personnel shall be described in the Support Management Plan, along with a narrative describing how they will meet the SSS requirements while performing their other duties and including procedures which ensure SFMTA always has a means to contact an SSS to request support.

14. Contractor shall provide the SSS staff with all the necessary tools to support SFMTA for timely correction of faults and failures responding in the timescales committed to Appendix I of the Agreement.

32.4.3 MAINTENANCE SUPPORT

1. Maintenance Support is described in MIL-HDBK-1390 Standard, in three levels of Maintenance. These three levels of maintenance are applicable to Hardware and Software as described in the following paragraphs.

2. SFMTA will perform first and Second-level Maintenance using SFMTA workforce or SFMTA third party contractors, in accordance with the Contractor's procedures and manuals approved by the SFMTA. SFMTA will follow the preventive maintenance schedule described in approved documentation provided by Contractor.

3. Contractor shall perform the third level of maintenance for all Software, Equipment and tools furnished under this Contract.

4. Contractor shall provide refresher maintenance training courses identified in Section 11 (Training) and training required by corrective actions identified by Contractor FRACAS program as part of the Support Services.

5. Contractor shall supply appropriate bench testing equipment and diagnostic tools which either SFMTA or Contractor can utilize on site for fault tracing, repairs and post-repair checkout.

6. Contractor shall indicate where its third level maintenance activities will be carried out (in relation to SFMTA network) and that such activity complies with all federal, state and municipal law.

32.4.3.1 HARDWARE MAINTENANCE LEVELS

1. First level of maintenance shall include the following:

    a. Preventive and corrective maintenance in the field applied to Line Replaceable Units (LRUs) or Lowest Line Replaceable Units (LLRUs) including repairing, inspecting, servicing, calibrating, lubricating, or adjusting Equipment, as well as the removal and replacement of defective LRUs and LLRUs.

    b. Repair actions that may be performed with the subsystem partially operational and/or fully powered to limit the impact on System Availability.

2. Second-level maintenance shall include all activities that are performed on removed parts, components, or equipment, including:

    a. Corrective maintenance in the shop on LRUs or LLRUs identified as defective during First-level Maintenance and returned to a central maintenance facility.

b. Calibrating, repairing, testing, or replacing damaged or unserviceable parts, components, or assemblies.

c. Use of a standard set of test and diagnostic equipment specified as Second Level Maintenance Devices (SLMD) in Section 21 to isolate and identify the defective assemblies or parts in defective LRUs or LLRUs.

d. Removal and replacement of defective assemblies or parts in the LRUs or LLRUs, with subsequent functional verification of the replacement(s).

3. Third-level maintenance shall include all activities that are performed on Equipment removed from the System and repaired off-site at a manufacturer repair facility, including:

a. Evaluation or repairs exceeding SFMTA's capability.

b. Inspecting, testing, calibrating, repairing, overhauling, refurbishing, reconditioning, and one-to-one replacement of defective parts, components or assemblies.

c. Modifications, enhancements, or upgrades to improve the Reliability or maintainability of the System (e.g., an increased mean time between failure [MTBF]) when the committed System Performance Targets are not achieved, and as specified in Section 30 (RAM).

d. Activities that do not enhance the System functionality.

e. All third level maintenance activities are required to be performed by the Contractor or Original Equipment Manufacturer (OEM) or the authorized agent of the Contractor or OEM.

32.4.3.2 SOFTWARE MAINTENANCE LEVELS

1. First level maintenance shall resolve or mitigate Software failures as quickly as possible and minimize their impact on the operation.

a. It includes rebooting of servers or other Equipment, reinitializing certificates, and clearing caches. These activities will be performed by SFMTA staff following the recommendations of Contractor's System Support Specialist.

b. It requires accurately recording all elements of the failures – how the failure manifested, how it was resolved, parameter recording of affected and influencing systems and any other data required by the FRACAS system. The SSS shall assist SFMTA staff in making these reports.

2. Second level maintenance shall include all activities that are performed with specialized technicians following the guidance and recommendations of the SSS and includes:

a. Installation and testing activities associated with Software modifications provided by Contractor.

b. System instrumentation for complex logging activities

c. Root cause analysis.

3. Third level maintenance shall include all activities that must be conducted offsite by Contractor, including:

a. Root cause analysis in lab simulation environment.

b. System Software or firmware modifications and testing

32.4.3.3 WARRANTY HANDOVER

1. Three months in advance of the end of the Warranty Period of each System Deployment Phase, Contractor shall submit a Support Services handover checklist [CDRL] to confirm date of handover and Open Items.

2. The checklist shall include all open FRACAS items including Software Bugs, Software Errors, Software Faults, Defects, Software Failures, and Software Problems.

3. After warranty expiration, Contractor shall supply spares and Special Tools required to perform both preventative and corrective maintenance on the System as part of the Support scope and at no additional charge to SFMTA as required by Section 32.4.1 (Provision of Equipment and Spare Parts).

32.4.4 OPERATIONS SUPPORT

1. Operations Support shall include at least the following, as further described in this Section:
    a. Technical Publications maintenance
    b. Operating Scenarios and Operating Procedures updates
    c. Simulators

32.4.4.1 TECHNICAL PUBLICATIONS MAINTENANCE

1. Contractor shall maintain the integrity and accuracy of the as-built technical publications issued during the Project.

2. Contractor shall maintain a system such that electronic and hard copy documentation is kept up to date and, appropriately distributed to relevant stakeholders. See Section 10 (Operations and Maintenance).

32.4.4.2 OPERATING SCENARIOS AND OPERATING PROCEDURES UPDATES

1. Every time the Software or Hardware is changed during the term of this Contract, Contractor shall submit a report summarizing the impact of these changes to SFMTA Operating Scenarios and/or Operating Procedures.

2. The report shall include an assessment of the impact any software update to RAMS performance.

3. Contractor shall submit revised operational scenarios and operating procedures if the above report indicates they must be changed.

32.4.4.3 SIMULATORS

1. If the ATS Operation Simulator (OSIM) requires Contractor Support to develop new scenarios or scripts, Contractor shall produce these scenarios or scripts upon request of SFMTA, with a limit of 5 per year, and transfer to SFMTA's OSIM.

2. If SFMTA can develop these scenarios or scripts without Contractor support, Contractor shall include instruction describing how to produce OSIM scenarios or scripts in the annual refresher training.

3. Contractor shall provide technical Support to all simulators provided under this Contract as part of the Support Services.

32.4.5 TRAINING

1. Contractor shall provide the training described in Section 11 as part of the Support Services.

2. Contractor shall update this training annually to cover recent incidents occurring in service with its customers and introduce new operational scenarios based on real-world experiences.

3. Contractor shall update its training courses and materials each time new functionality or operational and maintenance procedures are introduced during the Contract Term.

32.4.6 ENGINEERING SUPPORT

1. Contractor shall provide all engineering Support necessary to resolve technical Issues reported using the procedures described in Appendix I to the Agreement.

2. Contractor shall carry out all Root Cause Analyses described in Section 30.2.3 (Root Cause Analysis) as part of the Support Services included in this Contract.

3. The SSS shall monitor all active and recently closed Root Cause Analyses, reporting the status of each on a monthly basis.

32.4.6.1 OBSOLESCENCE MANAGEMENT

1. Contractor shall execute the Obsolescence Management Plan as specified in Section 14.

2. Contractor shall perform active management of the Obsolescence Management program through the duration of this Contract.

3. Contractor shall review the CBTC Product Roadmap [CDRL] with SFMTA on an annual basis following the initial issuance as provided in Section 14 (Obsolescence Management).

4. The CBTC Product Roadmap shall show the life cycle of the CBTC Hardware, Firmware, and Software products and their status, update requirements, upgrade options, and the evolution of the new product generation. In these reviews, Contractor shall submit recommendations and actions that maintain SFMTA ability to migrate to future product releases.

5. Contractor shall support SFMTA in planning for future Hardware upgrades related to future Contractor product releases. Hardware upgrades may include platform Hardware, radio or other computer system changes required to support Contractor's planned product development. These Hardware upgrades are not in the scope of the Support and will be managed as change orders or other procurements. Contractor shall submit ongoing recommendations and options that support SFMTA operational and capital budgeting and procurement processes. Contractor shall submit recommendations at the start of the Support Services effort and review yearly with SFMTA.

6. Contractor shall design and supply a System that complies fully with RAMS requirements of the Contract Specifications for the duration of the program regardless of SFMTA agreement to implement any Contractor recommended upgrades.

32.4.6.2 HARDWARE UPGRADES

1. Over the life of the System, SFMTA may require modifications to the CBTC System beyond the scope of maintenance Support Services or obsolescence management. These modifications will be necessary to adapt to operational requirements not originally envisioned at the start of the contracts.

2. Major Hardware Upgrades to the System will be managed through the Contract Modification process or separate contract, and negotiated on a case-by-case basis. The labor rates included in Appendix B to the Agreement, as adjusted for economic conditions according to Appendix B2.1.2, will form the basis for price negotiations.

3. As part of the Support Services provided for in this Contract and at no cost to the SFMTA, Contractor shall draft scopes of work, prepare estimates, and provide information or data as needed in preparation for future Upgrades, in response to SFMTA requests for information or requests for quotes (RFQ). These preparatory tasks enable SFMTA to budget and plan for Hardware and Software upgrades to the System which will later be initiated via a Contract Modification or separate contract. Such requests may arise from the Obsolescence Management Plan, the CBTC Product Roadmap, or SFMTA initiation.

4. SFMTA receipt of information or quote does not commit SFMTA to executing that work. Contractor shall not commence with work outside the scope of this Contract until SFMTA has issued a written Contract Modification and has received a separate Notice to Proceed (NTP) for that work.

32.4.7 SUPPORT QUALITY

1. Contractor shall develop and submit a Support Services Quality Management Plan (SSQMP) [CDRL] specific to the activities required during execution of the Support Services.

2. The SSQMP shall be an extension to the Quality Management Plan.

3. SSQMP development shall follow the applicable requirements in Section 5 (Quality Assurance and Quality Control).

4. The SSQMP shall describe the development of all specific quality control and audit activities that will occur during the Support Term.

5. The SSQMP shall include details on management of Configuration, version control of all documentation and assets, calibration and maintenance schedules, and maintenance of Codes and Standards.

6. The SSQMP shall include details on the process for achieving the RAM Program requirements of Section 30.

7. The SSQMP shall include details on the analysis of software failures as described in the IEEE 1633-2016 Software Reliability Engineering during operation.

32.4.8 CYBER AND SYSTEM SECURITY

1. Support Services work shall comply with the cyber and system security requirements and processes established in Section 6 (System Safety and Security Management).

2. Contractor shall supply Software upgrades and patches to maintain cyber and System security functions.

3. The cyber security Support shall be in addition to any measures that SFMTA and its own cyber security policy implement as well as any third-party IT cyber security protection measures which SFMTA adopts.

4. During the Support Term, Contractor shall lead a Cybersecurity Quarterly Review [CDRL] and collaborate and co-operate with SFMTA IT Department and SFMTA IT Security team, and other third parties to fully protect the System.

5. Contractor shall include an assessment of the impacts to RAMS performance of Software upgrades and patches required to maintain cyber and System security functions during the Cybersecurity Quarterly Review.

32.4.9 REGULAR SOFTWARE RELEASES

1. During the Support Term, SFMTA shall have the most up-to-date and current generation of the Contractor's CBTC product including any enhancements or other licensed services that Contractor provides to the industry.

2. Contractor shall implement all applicable System Software Upgrades compatible with SFMTA installed System Hardware at no additional cost to SFMTA, as part of the Support Services.

3. Contractor shall supply regular Software releases through the duration of the Support Services, at the frequencies specified in Appendix I.3 to the Agreement.

4. The Support Services shall include this program of regular Software releases for the term of this Contract.

5. Software releases shall include, but are not limited to:

    a. Updates and Upgrades necessary to keep the SFMTA version of the Software current with the latest release of Contractor's product,

    b. Security patches,

    c. Updates to address web-browser compatibility and operating system compatibility issues, and

    d. Software Bug fixes.

6. Contractor has identified COTS software as part of its offered solution and SFMTA has agreed to furnish and maintain the COTS software listed in Section 9.3 (Permanent SFMTA Furnished Items). SFMTA will apply all manufacturer recommended updates, upgrades and patches to that software. Contractor shall Update its Software as necessary to ensure compatibility with the most current version of any COTS software identified in Section 9.3 that the CBTC System relies upon to function or to meet the requirements in these Specifications.

7. All simulators shall receive Software updates at the same frequency specified in Appendix I.3 to the Agreement for the subsystem associated with the simulator (e.g., the ATS Operational Simulator Software shall be updated at the frequency specified for the ATS).

8. Contractor shall Update its Software and firmware, including simulators and tools, to maintain compatibility with the current version of the operating system (and web browser, for web-based Software) installed on the System Hardware.

9. As part of the Support Services, Contractor shall replace at no cost to SFMTA any operating system installed on System Hardware that has been declared end of life by its manufacturer.

10. Contractor shall, as part of the Support Services and at no additional cost to SFMTA, update the firmware of Contractor-provided Equipment so that all firmware is within 2 revisions of the latest manufacturer-provided release at all times during the Support Term.

11. Contractor shall perform, as part of the scope of the Support Services provided for in this Contract and at no additional cost to SFMTA, the Safety Certification, testing and Commissioning activities necessary to bring these regular Software releases into Revenue Service.

12. Contractor shall perform the Software Release Demonstrations described in section 31.4.6 (Software Release Demonstrations) for every Software release conducted as part of the scope of the Support Services.

13. The Contractor shall collect and document all software Errors, Software Faults, Defects, Software Problems, and Software Failures to verify the required RAMS performance metrics.

14. Contractor shall Update any of its simulator and tool Software as necessary to ensure compatibility between the latest Software release for the CBTC System and its associated simulators and tools.

15. If SFMTA has paid for the development of new features or functionality through a Contract Modification, Contractor shall include the new features or functionality in the next regularly scheduled Software release so that SFMTA will bear no additional cost for the Safety Certification, testing and Commissioning activities necessary to bring the Software release containing the new features or functionality into Revenue Service, unless otherwise specified in the Contract Modification.

16. Contractor shall include the resolution of any identified defect in the next planned release after Contractor has completed its Root Cause Analysis and SFMTA has approved the corrective action. SFMTA may require expedited releases for defects that impact service or operations. SFMTA may, at its sole discretion, waive performance fee reductions for a minor Open Item if the resulting corrective action is scheduled in an upcoming planned release. Open defects with no agreed resolution will reduce the monthly performance-based Support Fee as set out in Appendix B2 to the Agreement.

17. Contractor shall promptly notify SFMTA as soon as it becomes aware that a future Software release will not be compatible with SFMTA's installed Equipment, with enough advance warning that SFMTA has the opportunity to perform a Hardware Upgrade in order to continue receiving regular Software releases as part of its Support Services.

18. Contractor shall provide release notes for all Software releases.

19. Contractor shall give SFMTA a minimum of two weeks' notice before deploying a Software release.

20. Software releases shall be approved by the Technology Change Advisory Board as specified in Section 15.3, prior to deploying the release on SFMTA's CBTC System.

21. If the release requires testing that will require the use or reservation of any track, Contractor shall request track clearance and/or Closures according to SFMTA's Track and Tunnel Access Procedures provided in Appendix J to the Agreement. SFMTA may require Contractor to shift the day(s) of deployment and testing as a condition of approval.

22. Any documentation relating to Software releases shall comply with Design Life Cycle requirements in Section 4.2 (Design Life Cycle).

32.5 SUPPORT SERVICES CDRL TABLE

Table 32-32: Support Services CDRL Table

CDRL #	CDRL Title
32.01	CBTC Support Management Plan
32.02	Support Services Handover Checklist
32.03	CBTC Product Roadmap
32.04	Support Service Quality Management Plan
32.05	Cybersecurity Quarterly Review

33 RESERVED

34 RESERVED

35 CONTRACT DATA REQUIREMENTS LIST (CDRL)

35.1 PURPOSE

1. The Contract Data Requirement List (CDRL) listed below summarizes contractually required document submissions to SFMTA.

35.2 CONTRACT DATA REQUIREMENTS LIST (CDRL) SCHEDULE

1. Contractor shall submit the Project CDRLs according to Section 3.5 (CDRL) and shall adhere to the schedule of the relevant Design Review and other significant Project Milestones2.

2. Table 35-1 contains a list of required CDRLs. The list contained in this Section is not exhaustive of required submittals. When not specified in column "Due Date", the CDRL submission due date is twenty working Days in advance of the relevant Design Review or other Milestone of the Design Life Cycle as specified in Section 4.

3. Contractor may combine more than one of the documents listed as a CDRL in this Section, reducing the overall number of documents Contractor must provide. Contractor shall request SFMTA approval to combine multiple CDRLs in this way prior to delivering the single document. Contractor shall not be entitled to extra Contract Time or compensation if a request to combine CDRLs into a single document is denied.

Table 35-33: CDRL List

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
2.01	Scope Split	X										7 Days after NTP
3.01	Contractor Office and Warehouse Details	X										30 days after NTP
3.02	Organization and Staffing Plan	X										30 days after NTP
3.03	Project Management Plan (PMP)	X										30 Days after NTP
3.04	Interim Project Schedule											15 Days after NTP
3.05	Project Schedule											90 Days after NTP
3.06	Preliminary Contract Data Requirements List (CDRL)	X										15 Days after NTP
3.07	CDRL Production and Template Plan	X										
3.08	As-Built Documentation and Drawings										X	
3.09	Monthly Progress Report											30 Days after NTP and monthly
3.10	Monthly Progress Report Format											30 Days after NTP and monthly
3.11	Monthly Progress Schedule											Monthly
3.12	Four Week Schedule											Monthly
3.13	Recovery Schedule											As Applicable
3.14	Time Impact Evaluation											As Applicable
3.15	Material Items List (MIL)	X										30 Days after NTP and monthly
3.16	Material Delivery Process	X										30 Days after NTP
3.17	CBTC Concept of Operations and Maintenance											
4.01	System Engineering Management Plan (SEMP)	X	X									
4.02	Requirements Traceability Matrix			X	X							
4.03	Requirements Management Plan	X	X									

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
4.04	System Requirements Specification (SRD)		X	X	X							
4.05	Subsystem Requirements Specification (SSRD)			X	X							
4.06	System Functional Description (SFD)			X	X							
4.07	Software Project Management Plan (SPMP)	X	X									
4.08	System Integration Management Plan (IMP)	X	X									
4.09	Interface Management Plan	X	X	X								
4.10	System Verification & Validation (V&V) Plan	X	X									
4.11	Verification & Validation (V&V) Report (VVR)						X		X	X		
4.12	Performance Simulation Plan		X									
5.01	Quality Assurance Program Plan (QAPP)	X	X									
5.02	Confirmation of Subcontract Quality Assurance	X	X									
5.03	Quality Assurance Manuals				X							
5.04	Software Quality Assurance Plan (SQAP)	X	X									
5.05	Hardware Quality Assurance Plan (HQAP)	X	X									
5.06	Configuration Management Plan (CMP)	X	X									
5.07	Inspection and Test Program Plan (ITPP)	X		X								
5.08	Parts to Be Inspected by Statistical QC Methods	X		X								
5.09	Quality Management Report			X	X				X			40 days before passenger service
5.10	Quality Audit Report											Within one week of any Audit
6.01	Safety and Security Certification Plan (SSCP)	X	X									
6.02	Safety and Security Design Criteria		X									
6.03	Safety and Security Design Criteria Conformance Checklist			X								
6.04	Safety and Security Construction Specification Conformance Checklist			X								

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
6.05	Safety-Related and Security Testing Conformance Checklist			X								
6.06	Safety and Security Rules, Procedures, Training and Drills Conformance Checklist				X							
6.07	Hazard Resolution Conformance Checklist			X								
6.08	Safety and Security Certification Report									X		40 days before passenger service
6.09	System Safety Program Plan (SSPP)	X	X	X	X							
6.1	Software Assurance Plan (SAP)	X		X								
6.11	Safety Verification and Validation Plan (SVVP)	X		X								
6.12	Preliminary Hazard Analysis (PHA)			X								
6.13	System Hazard Analysis (SHA)				X							
6.14	Subsystem Hazard Analysis (SSHA)				X							
6.15	Interface Hazard Analysis (IHA)				X							
6.16	Operating and Support Hazard Analysis (O&SHA)				X							
6.17	Failure Modes and Effects and Criticality Analysis (FMECA)			X	X							
6.18	Fault Tree Analysis			X	X							
6.19	Cutover Hazard Analysis (CHA)				X							
6.20	Hazard Log			X	X				X			Continuous update
6.21	Safety Verification and Validation Report (SVVR)								X	X	X	
6.22	CBTC Concept of Safety Document	X		X								
6.23	Interim Safety Report (ISR)								X			15 days before each field test
6.24	Final Safety Report (FSR)				X				X			40 days before passenger service
6.25	System Security Plan (SSP)		X									
6.26	Threat and Vulnerability Assessment (TVA)			X								

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
6.27	Threat and Vulnerability Tracking List (TVTL)			X	X				X			
6.28	Cybersecurity Compliance Statement		X									
6.29	Cybersecurity Documentation Manual			X								
6.30	Draft Configuration Manual											At completion of any integration activities
6.31	Pre-Final Configuration Documentation Manual			X								Update of Draft Configuration Manual
6.32	Final Configuration Documentation Manual											Prior to System turnover to SFMTA
6.33	List of Applications Installed at Each Facility								X			
6.34	Wireless Network Documentation at Each Facility								X			
6.35	DED Details at Each Facility								X			
6.36	PLC and IED Documentation at Each Facility								X			
6.37	NSS Overview			X								
6.38	NSS Product Data Sheets and Literature				X							
6.39	Secure Coding Documentation				X							
6.40	NSS Functionality Design				X							
6.41	AAA Functionality				X							
7	No CDRLs in this section											
8.01	Deployment and Migration Plan	X		X								
8.02	Site – Specific Work Plans											
8.03	Construction Safety Program Plan						X					
8.04	Wayside Installation Plan	X				X						
8.05	Vehicle Installation Plan	X			X							
8.06	Vehicle Installation Interface List				X							
9.01	SFMTA Furnished Items Plan	X		X					X			

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
10.01	Updated Operating Scenarios			X								
10.02	Standard Operating Procedures				X							
10.03	Maintenance Plan	X		X	X							
10.04	List and description of all required operation and maintenance manuals and recommended additions				X							
10.05	Updated operating rules and procedures, O&M manuals, and/or operating bulletins during Migration				X							
10.06	Complete set of pertinent hardcopy manuals for each SFMTA facility				X							
10.07	CBTC System Description Manual				X							
10.08	CBTC Operation and Safety Manual				X							
10.09	ATS Operations Manual				X							
10.10	Wayside CBTC Installation, Repair, and Maintenance Manual				X							
10.11	Onboard CBTC Installation, Repair, and Maintenance Manual				X							
10.12	Data Communications Subsystem Installation, Repair, and Maintenance O&M Manual				X							
10.13	Central CBTC Installation, Repair, and Maintenance O&M Manual				X							
10.14	ATS System Administrator Manual				X							
10.15	CBTC System Simulator Operation Manuals				X							
10.16	CBTC Simulator Maintenance Manuals				X							
10.17	Software User Manuals				X							
11.01	Training Program Plan			X								
11.02	Catalog of Training Materials			X								
11.03	Training Curriculum Document			X								
11.04	Training Manuals				X							

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
11.05	Evaluation Materials				X							
11.06	Computer Based Interactive Course Materials				X							
11.07	Simulator Details				X							
11.08	Training Schedule				X							
12.01	Sustainability Plan	X	X									
13.01	Warranty Plan	X						X				
13.02	Warranty Procedures							X				
13.03	Warranty Item Tracking Database and Report							X				
13.04	List of Parts							X				
13.05	Barcoding Plan							X				
13.06	Safety Data Sheets (SDS)								X			
13.07	Equipment Asset Management System Integration Plan	X						X				
13.08	Asset Register											
13.09	Intangible Financial Assets List								X			
14.01	Obsolescence Management Plan (OMP)	X			X							
14.02	Sole source products listing	X										
16.01	CBTC System Architecture			X								
16.02	CBTC System Functional Specification			X								
16.03	CBTC Interlocking Rules Specification				X							
16.04	CBTC Worker Protection System Description				X							
16.05	CBTC Master Clock Design				X							
16.06	CBTC System Performance Simulation Report			X	X							
17.01	ATS Design Description Document			X	X							

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
17.02	ATS Software Architecture				X							
17.03	ATS Human Factors Analysis and Review Document				X							
17.04	ATS Alarm List and Priorities			X								
17.05	GUI Displays Description				X							
17.06	ATS Screen Displays for the Video Wall				X							
17.07	Detail and information to be included in the line overview and train tracking displays				X							
17.08	ATS Mobile Application Design Description				X							
18.01	ATO System Design				X							
18.02	ATO Software Architecture				X							
18.03	Berthing Safety Analysis				X							
18.04	Automatic Turnback Safety Analysis				X							
19.01	ATP System Design			X								
19.02	ATP Software architecture				X							
19.03	Safe Braking Analysis Model				X							
19.04	Train Presence Detection Design			X								
20.1	AMS Design Description Document			X								
20.2	AMS Data Document				X							
20.3	AMS Alarm List for ATS			X								
20.4	AMS Alarm List and Priorities			X								
20.5	AMS Reports Description			X								
20.6	NMS Design Description Document			X								
20.7	NMS Alarm List and Priorities			X								

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
20.8	NMS Reports Description			X								
21.01	Simulators Design Specification Document			X								
21.02	Simulators Manual				X							
21.03	Simulators Configuration				X							
21.04	Portable Test Equipment (PTE) Design Description Document				X							
21.05	Special Tools Package				X							
21.06	Maintenance Test Rack Design Description Document				X							
22.01	CBTC System Operating Modes		X									
24.01	CBTC onboard and Vehicle ICD			X								
24.02	Train Operator Display Human Factor Analysis			X								
24.03	Vehicle Test and Acceptance Plan			X								
24.04	Vehicle Installation Procedures			X								
24.05	Vehicle Test Procedures and Reports			X						X		
24.06	CBTC On-Board Equipment Migration Plan			X								
24.07	CBTC onboard Equipment Functional Descriptions (EFS)	X	X									
24.08	CBTC onboard Design Descriptions			X								
24.09	Graphical User Interface (GUI) Specification for Train Operator Display			X								
26.01	Data Communications Subsystem (DCS) Design Document			X	X							
26.02	DCS Interface Control Document (ICD)			X	X							
26.03	Structural Analysis Report				X							
26.04	RF Coverage Report							X	X	X		
26.05	Re-use of SFMTA Communications Infrastructure Document											
26.06	DCS Test Plan			X	X							

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
26.07	DCS Test Procedures				X							
26.08	IP Addressing Scheme				X							
26.09	DCS Device Naming and Labeling Scheme				X							
26.10	Equipment Data Sheets				X							
26.011	Propagation Maps of the Proposed Radio Coverage				X							
26.12	Carrier-to-Interference (C/I+N) Maps				X							
26.13	Link Budget				X							
26.14	Intermodulation Study for SFMTA Radio				X							
26.15	Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) Study Reports for LRVs				X							
26.16	Radio Site Characteristic Database				X							
26.17	Document Describing the Capacity of the Radio Communications Link and An Estimate of Expected Peak Load				X							
26.18	Report Describing the Characteristics of the RF Data Link Protocol				X							
26.19	Installation Plan for All Radio Communications Related Equipment				X							
26.20	Waiver for Product Data for the Radio Transceiver (if required)				X							
26.21	Proposed Design and Bill of Materials of Antenna Attachment to Catenary Structures				X				X			
26.22	Radio Frequency Re-Use Plan	X			X							
26.23	DCS Test Data and DCS Test Report								X			
26.24	Calibration Report for Test Equipment								X			
26.25	Report Verifying Proposed Coverage, Data Throughput and C/I +N Design has been achieved								X			
26.26	Radio Link Throughput Report								X			

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
26.27	Antenna and Transmission Line Sweep Test Report								X			
26.28	Connectors Weatherproofing Installation Photographs								X			
26.29	Lighting Protection System Grounding Points Photographs								X			
26.30	QoS Design Implementation				X							
27.01	Workstations Human Factor Analysis			X	X	X						
27.02	Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) Program Plan		X		X							
27.03	EMI/RFI Survey Plan	X	X	X	X	X						
27.04	EMI/RFI Survey Report				X							
27.05	Primary Control Center Floor Plan		X	X	X	X						
27.06	Backup Control Center Floor Plan		X	X	X	X						
27.07	Server Room Layouts		X	X	X	X						
27.08	Control Center Workstations Layout		X	X	X	X						
27.09	Wayside Signal Equipment Room Layout		X	X	X	X						
27.10	Hardware Design Description		X	X	X	X						
28.01	Application Programmable Interface (API) Design Document		X	X	X							
28.02	List of Published APIs			X	X							
28.03	Interface Control Document (ICD) - Video Wall Display			X	X							
28.05	ICD - Traffic Signal Controller (TSC)			X	X							
28.06	ICD – Drawbridge			X	X							
28.07	ICD - Freight Crossing (FC)			X	X							
28.08	ICD - Track Intrusion Detection System (TIDS)			X	X							
29.01	Demolition, Removal and Disposal Plan	X	X			X			X			

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
30.01	Reliability, Availability, and Maintainability (RAM) Plan		X	X	X	X						
30.02	Level of Repair Analysis (LORA)			X	X							
30.03	RAM Prediction Analysis			X	X							
30.04	RAM Apportionment			X	X							
30.05	Functional Failure Modes and Effect Analysis (FMEA)			X	X							
30.06	Component Failure Modes Effects and Criticality Analysis (FMECA)			X	X							
30.07	Fault Tree Analysis Diagram			X	X							
30.08	Fault Tree Analysis			X	X							
30.09	Maintenance Assessment for Preventive and Corrective Maintenance			X	X							
30.10	Software Reliability Analysis			X	X							
30.11	Reliability Block Diagram (RBD)			X	X							
30.12	RAM Demonstration Testing Plan	X		X	X					X		6 Months prior to the first RMDT Demonstration
30.13	RMDT Procedures											
30.14	Interim RMDT Plan and Procedure			X	X							
30.15	Reliability of Safety Critical Items			X	X							
30.16	RMDT Report									X		
31.01	First Article Configuration Inspection (FACI) Procedures							X				60 Days prior to the start of FACI
31.02	First Article Configuration Inspection (FACI) Drawing Package							X				60 Days prior to the start of FACI
31.03	Master Test Plan	X						X				
31.04	Test Program Plans							X				
31.05	Test and Regression Test Procedures							X				45 Days prior to the performance of the test
31.06	Testing and Commissioning Open Item List and description							X				
31.07	Post New Release Test Procedure							X				45 Days prior to the performance of the test

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
31.08	Test Reports							X				
31.09	Type Test Functional Block Diagram							X				
31.10	Type Test Procedures							X				
31.11	FAT Test Procedure								X			
31.12	Software Version Description								X			With each Software release from FAT to Project completion
31.13	Cutover Plan	X							X			
31.14	Post Installation Check Out (PICO) Procedures								X			45 Days prior to first PICO Test
31.15	Installation Verification								X			45 Days prior to first PICO Test
31.16	Site Engineering Test Procedures											
31.17	Vehicle Acceptance Test Reports								X			
31.18	Site Acceptance Test Procedures								X			
31.19	Shadow Mode Test Plan and Test Procedures	X							X			
31.20	Shadow Mode Test Procedures								X			
31.21	Procedure Verification Tests								X			
31.22	System Stress Test procedures								X			45 Days prior to the performance of the test
32.01	CBTC Support Management Plan											six months in advance of the start of the Pilot Operating Period
32.02	Support Services Handover Checklist											Three months in advance of the end of the Warranty Period of each System Deployment Phase
32.03	CBTC Product Roadmap		X									review with SFMTA on an annual basis during the Support Term
32.04	Support Service Quality Management Plan											six months in advance of the start of the Pilot Operating Period

CDRL #	Document Description	Plans	CDR	PDR	FDR	Construction Final Design	Development and Manufacturing	Delivery and Installation	Field Testing	RAM Demonstration	System Acceptance	Due Date
32.05	Cybersecurity Quarterly Review											During Support Term, Quarterly Review

Appendix B

Schedule of Prices and Calculation of Charges

Appendix B1 Schedule of Prices

The tables contained in this Appendix B1 (Schedule of Prices) are to be used consistent with the instructions provided in Appendix B2 (Calculation of Charges).

SYSTEM PROCUREMENT

Table 1 contains the prices from the Contractor's Price Proposal. All prices are in U.S. Dollars and include overhead and profit. The totals from this Table 1 are used to populate Appendix C (Milestone Schedule and Payment). Each line item in this table corresponds to a Phase. Payment Milestones in Appendix C are expressed as percentages of each of these line items. Payments for System Procurement will be made according to the procedures in Section B2.1.1 (Payment Procedures).

Table 1: System Procurement Price Schedule			
Line Items (Phases)	**Labor**	**Material**	**Total**
1. System Design	**$ 43,233,884.18**	**$ 0**	**$ 43,233,884.18**
2. Central Equipment, simulators, tools, documentation, and training	**$ 9,813,395.92**	**$ 8,211,811.12**	**$ 18,025,207.04**
3. On-board Equipment fitting	**$ 9,038,137.24**	**$ 9,089,433.94**	**$ 18,127,571.18**
4. Pilot Phase	**$ 18,839,460.44**	**$ 4,607,647.52**	**$ 23,447,107.96**
5. Subway Replacement*	**$ 12,622,811.28**	**$ 4,680,537.79**	**$ 17,303,349.07**
6. N Expansion*	**$ 6,444,600.55**	**$ 1,040,338.74**	**$ 7,484,939.29**
7. T Expansion*	**$ 6,266,574.13**	**$ 1,124,723.09**	**$ 7,391,297.22**
8. K&M Expansions*	**$ 6,279,290.31**	**$ 1,974,809.12**	**$ 8,254,099.43**
9. J Expansion*	**$ 3,324,029.66**	**$ 607,862.70**	**$ 3,931,892.36**

10. L Expansion*	**$ 4,021,914.64**	**$ 293,174.55**	**$ 4,315,089.19**
Total System Procurement Price	**$ 119,884,098.35**	**$ 31,630,338.57**	**$ 151,514,436.92**

*May be adjusted for economic conditions in accordance with Section B2.3.2 (Economic Price Adjustment).

Table 2 (Pricing for Procurement Options) contains the pricing for procurement Options. The SFMTA may opt to equip additional railcars beyond the 219 included in the Total System Procurement Price, up to a limit of 30 additional railcars. The per-car price of equipping additional LRVs is stated in Table 2, Option 1.

The SFMTA also has an Option to equip its Heritage streetcars and maintenance Vehicles as part of the Project. The prices for these Options are included in Table 2 as Option 2 and Option 3. The Contractor's design may not require equipping the Heritage streetcars and maintenance Vehicles to meet the requirements in the Contract Specifications. If the Contractor's design does not require equipping the Heritage streetcars and maintenance Vehicles, Option 2 and Option 3 may be priced at $0.

If the Contractor has filled out the optional tables on pages F-101 to F-114 of the RFP, then the Unit Prices for Option 2 will be the prices listed in those tables, for each type of Heritage Vehicle. If the Contractor does not fill out the optional pages, the Unit Price for Option 2 will be the Total Price divided by 50.

Table 2: Pricing for Procurement Options. Price sheet for Options for procurement. These original Contract Rates will be adjusted for economic conditions in accordance with procedures in Section B2.3.2 (Economic Price Adjustment) at the time the Option is exercised.

	Price per kit	**Total Price**
1. Option 1. Additional onboard fitment per LRV4 railcar up to a maximum of 30 LRVs (including both Equipment and Services required to equip each LRV)	**$ 145,647.11 / vehicle**	**$ 4,369,413.15**
2. Option 2. Additional onboard Equipment kits per Heritage streetcar up to a maximum of 50 Vehicles (including Equipment, testing, and services required to equip each streetcar)	**$ 220,578.60 / vehicle**	**$ 11,028,929.75**

Table 2: Pricing for Procurement Options. Price sheet for Options for procurement. These original Contract Rates will be adjusted for economic conditions in accordance with procedures in Section B2.3.2 (Economic Price Adjustment) at the time the Option is exercised.		
	Price per kit	**Total Price**
3. Option 3. Additional onboard Equipment kits per maintenance Vehicle up to a maximum of 30 Vehicles (including Equipment, testing, and services required to equip each streetcar)	**$ 285,233.27 / vehicle**	**$ 8,556,998.06**
4. Option 4. Additional Interlocking Equipment and design services to furnish up to 10 additional Interlockings as described in Contract Specifications Section 16.2 (System Architecture).	**$ 764,187.40 / Interlocking**	**$ 7,641,873.99**
5. Option 5. Additional Central Emergency Stop Buttons for Backup Control Center as described in Contract Specifications Section 27.7.3 (Workstations).	**Lump sum**	**$ 656,305.00**
6. Option 6. Additional design services common to Heritage and/or Maintenance Vehicles, from PDR to Final Design.	**Lump Sum**	**$ 12,508,199.93**
Total Price of All Procurement Options		**$ 44,761,719.89**

SYSTEM SUPPORT

Table 3 (System Support Prices) sets out the Support Fees the SFMTA will pay for the base Support Term and each of the 5-year Options. The table also has a row showing the full support fees that could be paid to the Contractor prior to Final Acceptance, using the phasing in of support described in Section B.2.2.5 (Calculation of Phase-in Adjustments). Column A states the original monthly support fees from the Contractor's Price Proposal, in 2024 dollars.

The Monthly Support Fee will be adjusted annually to compensate for economic conditions as described in Section B2.3.2 (Economic Price Adjustment). The resulting annual adjusted Monthly Support Fee will be stated in Column B. The values in Column B will be used to calculate performance-based adjustments, as described in Section B.2.2.2 (Payment Procedures).

Column D states the total support fees due the Contractor over the full Support Term and Optional extensions. Column D = Column A × Column C.

All prices are in USD and include overhead and profit.

Table 3: System Support Prices				
	A. Original Monthly Support Fee (Contract Rate)	**B. Adjusted Monthly Support Fee**	**C. Number of Months**	**D. Total Support Fee**
0. Phase-In Support Fees, not to exceed				**$ 11,115,083.00**
1. Initial Support Term: 10-year System support services	**$ 373,511.38 / month**	**$ ___ / month**	**120**	**$ 44,821,366.17**
2. Option 7: first 5-year extension for System support services	**$ 446,139.26 / month**	**$ ___ / month**	**60**	**$ 26,768,355.82**
3. Option 8: second 5-year extension for	**$ 518,344.40 / month**	**$ ___ / month**	**60**	**$ 31,100,664.05**

System support services				
Total Support Service Price				**$ 102,690,386.04**

Rates for Additional Services

Table 4 (Hourly Labor Rates by Position) state Contractor's Fully Burdened Hourly Labor Rates, for the purposes of calculating the costs of additional design/software work under a Change Order or Contract Modification. Contractor shall use these rates when calculating its estimates for all Change Orders and Contract Modifications. These original Contract Rates may be adjusted for economic conditions in accordance with procedures in Section B2.3.2 (Economic Price Adjustment) at the time SFMTA issues a Request for Contract Change or receives a Request for Contract Change from Contractor.

Table 4 states hourly rates for Contractor's personnel assigned to the Project. It is not necessary to include the names of individual personnel.

Table 4: Hourly Labor Rates by Position.

Position / Classification	Education / Experience	Hourly Rate
Project Director	Technical Degree	$325.00
Project Manager	Technical Degree, 15 years' experience	$290.00
Sr. Software Engineer	Technical Degree, 10 years' experience	$260.00
Electrical Engineer	Technical Degree, 10 years' experience	$235.00
Software Engineer	Technical Degree, 10 years' experience	$235.00

Table 4: Hourly Labor Rates by Position.		
Position / Classification	**Education / Experience**	**Hourly Rate**
Planner	Planning Skills, 10 years' experience	$220.00
Project Admin	2 years' experience	$175.00
Project Cost Controller	Degree, 5 years' experience	$185.00
Contract Manager	Degree, 5 years' experience	$230.00
Procurement Specialist	Degree, 5 years' experience	$185.00
Quality Analyst	Technical Degree, 5 years' experience	$185.00
Publication Specialist	2 years' experience	$175.00
System Operations	Technical Degree, 5 years' experience	$230.00
System Design	Technical Degree, 5 years' experience	$230.00

Table 4: Hourly Labor Rates by Position.		
Position / Classification	**Education / Experience**	**Hourly Rate**
System Engineering Manager	Technical Degree, 15 years' experience	$265.00
Project Design Authority	Technical Degree, 10 years' experience	$260.00
Data Comms Engineer	Technical Degree, 10 years' experience	$250.00
RAM Engineer	Technical Degree, 10 years' experience	$235.00
Site Infrastructure Designer	Technical Degree, 10 years' experience	$235.00
Senior Safety and Safety Assurance	Technical Degree, 15 years' experience	$290.00
Senior Quality Assurance and Configuration	Technical Degree, 15 years' experience	$265.00
Senior Signaling Designer	Technical Degree, 15 years' experience	$290.00
Safety and Safety Assurance	Technical Degree, 5 years' experience	$230.00

Table 4: Hourly Labor Rates by Position.		
Position / Classification	**Education / Experience**	**Hourly Rate**
Quality Assurance and Configuration	Technical Degree, 5 years' experience	$230.00
Signaling Designer	Technical Degree, 5 years' experience	$260.00
Factory or Field Technician	Technical Degree, 2 years' experience	$180.00

Table 5. Spare Part Price Sheet. *Price sheet for billing Reimbursable Parts under the terms provided in Section B2.2.3 (Monthly Support Fee Calculation). These Contract Rates will be adjusted in accordance with procedures in Section B2.3.2 (Economic Price Adjustment) at the time of invoice. Attach additional pages as necessary*

The Table 5 provided by the Contractor will be attached as a separate file.

Appendix B2 Calculation of Charges

Contractor's compensation shall be calculated using the following tables and procedures.

B2.1 System Procurement Procedures

B2.1.1 Payment Procedures

B2.1.1.1 Milestone Payments. From NTP until Final Acceptance, the SFMTA will pay Contractor the amounts set out in Appendix C (Milestone Schedule and Payment), either following the completion of the Milestone or proportional to progress made towards the Milestone, as described in this Section. Major Milestones are marked in boldface type in Appendix C and are marked with "MM" in the corresponding row.

B2.1.1.1.1 Payment Made Upon Completion. The SFMTA will only make payment for a Major Milestone after the SFMTA has approved all Work for that Milestone, as described in the Project Management Plan. Approval for CDRL submittals is described in Contract Specifications Section 3.5.1.4 (SFMTA Review).

B2.1.1.1.2 Progress Payments. The Contractor may invoice for progress made against non-major Milestones or Option Payments on a monthly basis, or less frequently. SFMTA will only make payments for Major Milestone work following completion of that Work.

B2.1.1.2 Option Payments. The SFMTA will pay Contractor for Work performed and Equipment delivered under Options for additional Vehicle Fitments from Table 2 (Pricing for Procurement Options), upon SFMTA's Acceptance of the delivered and tested Equipment. Contractor may invoice for progress made based on the number of kits delivered, tested and accepted.

B2.1.2 Retention. The SFMTA will retain five percent (5%) of each payment to Contractor, as provided in General Provisions, Section 4.5.3.

B2.2 System Support Procedures

B2.2.1 Monthly Support Fee. In exchange for Support Services described in Contract Specifications, Section 32 (Support Services), the SFMTA will pay Contractor a Monthly Support Fee. The Monthly Support Fee is stated in Table 3 (System Support Prices) for the Initial Support Term and Contract Term extension Options.

B2.2.2 Payment Procedures. Starting on the first day of each month, Contractor shall perform the calculations described in this Section B2.2 to adjust the Monthly Support Fee based on System and Contractor performance for the previous calendar month, and submit an invoice to SFMTA for payment no later than the fifth day of the month.

B2.2.2.1 Invoice Start Date. The Contractor shall not bill for Support Services until the first day of the month following the SFMTA's Conditional Acceptance of the Subway Replacement Phase.

B2.2.2.2 Invoice Format. The Contractor's monthly invoice shall be in the format described in General Provisions, Section 4.5.5 (Invoice Format) and show Contractor's adjustments and calculations using the procedures in this Section B2.2 (System Support Procedures).

B2.2.2.3 Payment. The SFMTA will verify Contractor's calculation of compensation owed and performance adjustments, and will issue payment to Contractor of the adjusted amount based on its verification.

B2.2.2.4 Disputes. Disagreements between the Parties over the adjusted Monthly Support Fee shall be resolved using the Dispute Resolution Procedures provided for in General Provisions, Section 12.8 (Dispute Resolution Procedures).

B2.2.3 Monthly Support Fee Calculation. The Monthly Support Fee set out in Appendix B1 (Schedule of Prices), Table 3, Column A will be adjusted by SFMTA to account for economic conditions in accordance with Section B2.3.2 (Economic Price Adjustment), and the adjusted amounts will be inserted into Appendix B1 (Schedule of Prices), Table 3, Column B annually, beginning after Final Acceptance. The Monthly Support Fee will be further adjusted based on performance in accordance with Section B.2.2.3.2. Prior to Final Acceptance, the Monthly Support Fee will be "phased-in" depending on the number of Deployment Phases which have received Conditional Acceptance by the SFMTA, as set out in Appendix B2, Table 8. The Monthly Support Fee will be further reduced if Contractor does not complete RAM Demonstration Testing, as described below in Section B2.2.3.3.

B2.2.3.1 Adjustments for Phase-In. For each of the months following Subway Conditional Acceptance but prior to Final Acceptance, Contractor shall multiply the Monthly Support Fee from Appendix B1 (Schedule of Prices), Table 3, Column A by the Phase-in Adjustment Factor calculated using the instructions in Section B2.2.5 (Calculation of Phase-in Adjustments), below.

B2.2.3.2 Adjustments for Performance. For each of the months following Final Acceptance, Contractor shall multiply the Adjusted Monthly Support Fee from Appendix B1 (Schedule of Prices), Table 3, Column B by the Performance Adjustment Factor from Appendix B2 (Calculation of Charges), Table 7, Row 7 calculated using the instructions in Section B2.2.4, below.

B2.2.3.3 Adjustment for Failure to Demonstrate RAM. If Contractor has initiated but not completed the Initial Reliability and Maintainability Demonstration Testing (RMDT) or the Contractor has initiated but not completed the Final RMDT as specified in Contract Specifications, Section 30.6.5 (RAM Verification – Reliability, Availability and Maintainability Demonstration Testing, the Monthly Support Fee, after all adjustments described in this Section B2.2.3 have been made, shall be reduced by 50 percent.

B2.2.3.4 Reimbursement for Spare Parts. Contract Specifications, Section 32.4.1 (Provision of Equipment and Spare Parts) of the Contract Specifications permits Contractor to invoice the SFMTA for Reimbursable Parts. The Contractor shall use the prices from Appendix B1 (Schedule of Prices), Table 5, as adjusted according to B2.3.1 (Economic Price Adjustment), to calculate this reimbursement and add this amount to the monthly support invoice as a separate line item.

B2.2.4 Calculation of Performance-Based Monthly Support Fee Adjustments. Up to 20% of the Monthly Support Fee is variable based on Contractor's and System Performance relative to the Performance Targets listed in Appendix I (Performance and Service Level Requirements). If Contractor's and System Performance meets the Performance Targets, Contractor receives 100% of the Monthly Support Fee. For performance exceeding the targets, Contractor may receive up to a 140% adjustment of the variable portion of the support fee (totaling 108% of the monthly support Fee), as set out in Tables 6 and 7 using the instructions in this section. For performance not meeting the targets, the variable portion will be reduced, according to the schedule in Table 6. The variable portion can be reduced to zero, in which case Contractor will receive 80% of the Monthly Support Fee, which is the minimum, fixed portion of the fee. Examples of these calculations are included in the RFP No. SFMTA-2022-40-FTA, Appendix N.

B2.2.4.1 Performance Calculations. For each month that a Support Fee is invoiced, Contractor shall calculate Availability, Reduction in Operating Margin Events, Loss of Critical Function, and Support Tickets Exceeding Resolution Time according to the methodology provided in Contract Specifications, Section 30 (Reliability,

Availability, and Maintainability (RAM)). The SFMTA will review and verify Contractor's calculations.

B2.2.4.2 Availability Performance Score Calculation. Contractor shall enter the month's availability, A_s, into the formula in Row 1. The formula yields the percent. Round down to the nearest value of 140%, 120%, 100%, 80%, 60%, 40%, 20%, 0%. If the formula produces a value less than 0, use 0%. This is the Performance Score for Availability. Enter this Value in Row 1, Column B of Appendix B2 (Calculation of Charges), Table 7.

B2.2.4.3 Other Performance Score Calculations. The Contractor shall compare the actual number of Operating Margin Events, Loss of Critical Function events and open Unsatisfactory Issues during the month and compare those counts to the values in Appendix B2 (Calculation of Charges), Table 6.

B2.2.4.3.1 For each of these three parameters, the Contractor shall select the column corresponding to the largest number that is equal to or lower than the actual performance this month. If no values in the table are lower than the actual performance, the Contractor shall select the 140% column.

B2.2.4.3.2 For the Unsatisfactory Issues row, the Contractor shall select the 120% column if there have been zero Unsatisfactory Issues this month and the two months preceding for a total of three (3) consecutive months. The Contractor shall select the 140% column if there have been zero Unsatisfactory Issues this month and the five months preceding for a total of six (6) consecutive months.

B2.2.4.3.3 Use the Performance Score from the header (i.e., 140%, 120%, 100%, 80%, 60%, 40%, 20%, or 0%) of the selected column in Table 6 and enter those percentages into Column B of Table 7 for the corresponding parameters. For each column selected at 140% or 120%, the Contractor shall enter "100%" into Column B of Table 7 in place of 140% or 120% if ANY of the four parameters is less than 100% this month.

B2.2.4.4 Calculation of Performance Adjustment Factor. To calculate the Performance Adjustment Factor, the Contractor shall multiply each parameter's Performance Score in Column B of Table 7 by the corresponding weights in Column C of Table 7. Add the four weighted Performance Scores together and enter into Row 5, Column D of Table 7. Add 80% (representing the fixed fee) to this total

and enter into Row 7, Column D of Table 7. The result is the Performance Adjustment Factor.

The Contractor shall use Table 6 (Calculation of Performance Scores) to convert the monthly performance of the CBTC System and Contractor into Performance Scores in accordance with the procedures set out in Section B2.2.4 (Calculation of Performance-Based Monthly Support Fee Adjustments). The Contractor shall then enter resulting Performance Scores into Table 7 for calculation of the monthly Performance Adjustment Factor.

Table 6: Calculation of Performance Scores

Weight	Parameter	Performance Targets	Performance Score							
			140%	120%	100%	80%	60%	40%	20%	0%
4%	Availability A_s	99.96%	99.99% or greater	99.98%	99.96%	99.94%	99.92%	99.90%	99.88%	< 99.98%
4%	Reduction in Operating Margin Events	88	1 or less	4	7	9	11	13	15	> 15
2%	Loss of Critical Function	1	0 in past 2 years	0 in past 12 months	1 in past 12 months	1 in past 9 months	1 in past 6 months	1 in past 3 months	2 in past 12 months	> 2 in past 12 months
10%	Unsatisfactory Issues Tally	0	**	*	0	5	10	15	20	> 20

* 120% awarded for three consecutive months with zero Unsatisfactory Issues

**140% awarded for six or more consecutive months with zero Unsatisfactory Issues

The Contractor shall fill in Table 7 (Calculation of Performance Adjustment Factor) each month to calculate the Performance Adjustment Factor in accordance with the procedures in Section B2.2.4 (Calculation of Performance-Based Monthly Support Fee Adjustments). Contractor shall attach completed versions of these tables to each invoice. The SFMTA will review these calculations before paying Contractor's invoice.

	Table 7: Calculation of Performance Adjustment Factor			
	Column A	Column B	Column C	Column D
Row	Parameter	Performance Score	Weight	Weighted Performance Score
1	Availability		× 4% =	
2	Reduction in Operating Margin Events		× 4% =	
3	Loss of Critical Function		× 2% =	
4	Unsatisfactory Issues Tally		× 10% =	
5	**Sum of Weighted Performance Scores**			
6	Add monthly fixed fee			+ 80%
7	**Performance Adjustment Factor**			

B2.2.5 Calculation of Phase-in Adjustments. The System will be implemented in Phases, as described in Contract Specifications, Section 8 (Deployment, Migration and Acceptance). The Support Services that Contractor will provide during a Deployment Phase will begin at the end of that Phase's Warranty Period. Until Final Acceptance, the Monthly Support Fee will be pro-rated according to Appendix B2 (Calculation of Charges), Table 8 to account for the fact that the SFMTA will not receive Support Services for the portions of the System that the SFMTA has not yet accepted.

B2.2.5.1 Calculation of Phase-in Adjustment Factor. To calculate the Phase-in Adjustment Factor, the Contractor shall add the corresponding Phase-in Adjustment Percentage from Appendix B2 (Calculation of Charges), Table 8 for each of the Phases which the SFMTA has given Conditional Acceptance.

B2.2.5.2 Sunset of Phase-in Adjustment Factor. Starting on the first of the month after Final Acceptance, the Phase-in Adjustment Factor will no longer be calculated and is instead set at 100%.

Table 8: Support Payment Schedule for Phased Delivery

Phase	Phase-In Adjustment Percentage
1. Pilot Phase & Subway Replacement	50%
2. N Expansion	10%
3. T Expansion	10%
4. K&M Expansions	10%
5. J Expansion	10%
6. L Expansion	10%
TOTAL ALL PHASES	**100%**

B2.3 General Procedures

B2.3.1 Economic Price Adjustment. SFMTA will make certain adjustments to the Contractor compensation, in accordance with the terms of this Section B2.3.1 (Economic Price Adjustment), below. Price adjustments will apply to:

a. System Procurement Price Schedule line items listed in Appendix B1 (Schedule of Prices), Table 1, line items 5 – 10.

b. Pricing for Options listed in Appendix B1 (Schedule of Prices), Table 2, all line items.

c. System Support prices, listed in Appendix B1 (Schedule of Prices), Table 3, line items 1 -3.

d. Hourly rates for labor, listed in Appendix B2 (Calculation of Charges), Table 4, all line items

e. Spare part prices, listed in Appendix B2 (Calculation of Charges), Table 5, all line items.

f. Liquidated damages, as specified in Section 5.8.4 (Liquidated Damages for Unauthorized Replacement of Key Personnel), 5.18.9 (Liquidated Damages for Transit Service Interruption) through 5.18.11 (Liquidated Damages for Late Delivery).

B2.3.1.1 Sole Remedy for Cost Increases. An economic price adjustment under this Section shall be Contractor's sole remedy for any increases in Contractor's costs arising from or related to economic inflation.

B2.3.1.2 Adjustment Timing

B2.3.1.2.1 System Procurement Price Schedule line items listed in Appendix B1 (Schedule of Prices), Table 1 items 1 – 4 shall not be adjusted.

B2.3.1.2.2 System Procurement Price Schedule line items listed in Appendix B1 (Schedule of Prices), Table 1 items 5 - 10 will be adjusted only once upon commencement of the associated Deployment Phase.

B2.3.1.2.3 Prices for the Options listed in Appendix B1 (Schedule of Prices), Table 2, will be adjusted only once, at the SFMTA issuance of notice of intent to exercise the Option, if that exercise occurs more than three years from Notice to Proceed, in accordance with the price adjustments set out in this Appendix.

B2.3.1.2.4 System Support prices, including prices of Options, listed in Appendix B1 (Schedule of Prices), Table 3, will be adjusted once upon commencement of the support, and will be adjusted yearly thereafter on the anniversary date of the commencement of the Support period.

B2.3.1.2.5 Hourly rates for labor listed in Appendix B1 (Schedule of Prices), Table 4, will be adjusted once per Fiscal Year.

B2.3.1.2.6 Spare part prices, listed in Appendix B1 (Schedule of Prices), Table 5, will be adjusted once upon commencement of the support, and will be adjusted yearly thereafter on the anniversary date of the commencement of the Support period.

B2.3.1.2.7 The Liquidated Damages amounts in Sections 5.8.4 (Liquidated Damages for Unauthorized Replacement of Key Personnel), 5.18.9 (Liquidated Damages for Transit Service Interruption) through 5.18.11 (Liquidated Damages for Late Delivery) shall be adjusted when and at the same rate as the prices identified in Section B2.3.1 (Economic Price Adjustment) are adjusted.

B2.3.1.3 Economic Price Adjustment Calculation. The SFMTA will calculate adjustment to prices for unforeseen market or labor conditions using the North American Industry Classification System (NAICS) labor and material indices published by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). These indices may be found at:

a. https://www.bls.gov/iag/tgs/iag334.htm,

b. www.bls.gov/iag/tgs/iag335.htm,

c. www.bls.gov/iag/tgs/iag336.htm, and

d. https://www.bls.gov/iag/tgs/iag54.htm.

B2.3.1.3.1 Labor Indices. The SFMTA will calculate adjustment to prices for changing labor conditions using the average of following indices, equally weighted:

a. Series CEU3133500003 – Average hourly earnings of all employees index for the NAICS Manufacturing Series, Code 335, Electrical Equipment, Appliance and Component Manufacturing,

b. Series CEU3133600003 – Average hourly earnings of all employees index for the NAICS Manufacturing Series, Code 336, Transportation Equipment, and

c. Series CEU6054000003 – Average hourly earnings of all employees index for the NAICS Manufacturing Series, Code 541, Professional, Scientific, and Technical Services.

B2.3.1.3.2 Material Indices. The SFMTA will calculate adjustment to prices for changing market conditions using:

a. Series PCU334419334419 – Producer Price Index (PPI) for the NAICS Manufacturing Series, Code 3344, Semiconductor and Other Electronic Component Manufacturing,

b. Series PCU335---335--- – Producer Price Index (PPI) for the NAICS Manufacturing Series, Code 335, Electrical Equipment, Appliance and Component Manufacturing, and

c. Series PCU336---336--- – Producer Price Index (PPI) for the NAICS Manufacturing Series, Code 336, Transportation Equipment.

B2.3.1.3.3 Determination of Adjustment Factor

B2.3.1.3.3.1 The adjustment factor is the ratio of the current index to the base index. There are two adjustment factors, a labor adjustment factor and a material adjustment factor.

B2.3.1.3.3.2 SFMTA will determine the base labor and material indices by calculating the arithmetic mean (average) of the final published indices referenced above for the three months prior to the date of Notice to Proceed.

B2.3.1.3.3.3 SFMTA will determine the current labor and material indices by calculating the arithmetic mean of the final published indices referenced above for the three months prior to the date of adjustment.

B2.3.1.3.4 Determination of Adjusted Price

B2.3.1.3.4.1 SFMTA will use the Contract Amount stated for Work not yet performed (excluding the sum prices for all Contract Modifications and Work delayed by Contractor) stated in Table 1 (System Procurement

Price Schedule) of Appendix B1 (Calculation of Charges) as the basis for adjustment.

B2.3.1.3.4.2 System Procurement Prices

B2.3.1.3.4.2.1. Appendix B1 (Schedule of Prices), Table 1 states the labor and material prices for each System Procurement Price Schedule line item to be adjusted.

B2.3.1.3.4.2.2. SFMTA will adjust the labor price for each System Procurement Price Schedule line item by multiplying the price by the labor adjustment factor.

B2.3.1.3.4.2.3. SFMTA will adjust the material price for each System Procurement Price Schedule line item by multiplying the price by the material adjustment factor.

B2.3.1.3.4.2.4. SFMTA will add the adjusted labor and material prices together to produce the adjusted total price.

B2.3.1.3.4.2.5. SFMTA will modify Appendix B1 (Schedule of Prices), Table 1 with the adjusted labor, material and total prices for each line item, as applicable.

B2.3.1.3.4.2.6. SFMTA will modify the "Milestone Payment" column in Appendix C (Milestone Schedule and Payment) with the adjusted total price from Appendix B1 (Schedule of Prices), Table 1 (corresponding to 100%), and with recalculated values for each of the subordinate Milestones based on the percentages of that total price specified in Appendix C, for each phase to be adjusted.

B2.3.1.3.4.2.7. No Milestone or Phase will be adjusted beyond the date committed to in Appendix C (Milestone Schedule and Payment). If Contractor delays the Work causing delay to completion of a Milestone, Project completion date, or other deadline tied to compensation, SFMTA will apply the adjustment using the dates stated in Appendix C (that is, excluding the period(s) of delay).

B2.3.1.3.4.3 Prices for Options listed in Appendix B1, Table 2. SFMTA will adjust the material price for each Option by the ratio of current material

indices to base material indices applicable when the SFMTA issues notice of intent to exercise the Option.

B2.3.1.3.4.4 System Support Prices, including Options, listed in Appendix B1, Table 3.

B2.3.1.3.4.4.1. SFMTA will use the monthly support fee from the "Original Monthly Support Fee" column in Appendix B1 (Schedule of Prices), Table 3 for this calculation.

B2.3.1.3.4.4.2. The monthly support fee will be broken down by the percentages of labor and material as follows: 40% labor and 60% material.

B2.3.1.3.4.4.3. SFMTA will adjust the labor portion for the monthly support fee by multiplying the labor portion of the monthly support fee by the labor adjustment factor.

B2.3.1.3.4.4.4. SFMTA will adjust the material portion for the monthly support fee by multiplying the material portion of the monthly support fee by the material adjustment factor.

B2.3.1.3.4.4.5. SFMTA will add the adjusted labor and material fees together to produce the adjusted total monthly support fee.

B2.3.1.3.4.4.6. SFMTA will modify the "Adjusted Monthly Support Fee" column in Appendix B1 (Schedule of Prices), Table 3 with the adjusted total monthly support fee. SFMTA will not modify the "Original Monthly Support Fee" column.

B2.3.1.3.4.5 Hourly Rates for Labor listed in Appendix B1 (Schedule of Prices), Table 4. Each June, SFMTA will calculate and publish the labor adjustment factor to be used for the following Fiscal Year. When providing a Proposal in response to an SFMTA request, Contractor shall adjust the hourly rates by multiplying the labor hourly rates by the most recent labor adjustment factor published by SFMTA and include this calculation in the Proposal. The adjusted hourly rates shall be used to calculate the Contract Modification price.

B2.3.1.3.4.6 Spare Part Prices listed in Appendix B1 (Schedule of Prices), Table 5. Each June, SFMTA will publish the material adjustment factor to be used for the following Fiscal Year. When invoicing the SFMTA for Reimbursable Parts, Contractor shall adjust the spare part prices by multiplying the prices by the most recently published material adjustment factor as of the invoice date and include this calculation in the invoice. The adjusted prices shall be used to calculate the reimbursement.

B2.3.1.3.4.7 Liquidated Damages. The Liquidated Damages specified in General Provisions Section 5.18.9 through 5.18.11 (Liquidated Damages for Late Delivery) shall be adjusted by multiplying the liquidated damages amounts by the most recent labor adjustment factor calculated by SFMTA.

B2.3.1.4 Limit of Adjustments

B2.3.1.4.1 Annual Economic Price Adjustment Cap. The cumulative price adjustments shall not exceed a compounded average increase or decrease of 6 percent per year (calculated relative to the prices stated in the Agreement for the immediately preceding year).

B2.3.1.5 Adjustment Procedure.

B2.3.1.5.1 Requests. Economic Price Adjustments will occur according to the adjustment timing in Section B2.3.2.2 (Adjustment Timing). The SFMTA will calculate the price adjustments using the procedures in Section B2.3.2.3 (Economic Price Adjustment Calculation).

B2.3.1.5.2 Contract Modification. Adjustment of prices and adjustment of liquidated damages shall be stated in a Contract Modification executed by the Parties, as described in General Provisions, Section 12.5 (Contract Modifications and Change Orders).

B2.3.1.5.3 Exchange Rate Risk. The City will not make economic adjustments to Contractor compensation to adjust for losses from fluctuations in the value of foreign currencies in relation to the United States Dollar.

Appendix C

Milestone Schedule and Payment

Note: Major Milestones are indicated in **bold** in the following Table and by "MM" in the corresponding row. Refer to Section B2.1.1 (Payment Procedures) for more details.

Milestone payments in phases marked with (*) will be adjusted in accordance with Appendix B2.3.2. Prices listed below are subject to 5% payment reduction for Retention, as provided in General Provisions, Section 4.5.3.

The schedule included below in the "Days from NTP" column is the deadline for Contractor to complete the Work and/or submit Deliverables constituting the listed Milestone and does not correspond to the date Contractor can expect to be paid for that Milestone. SFMTA will pay the Contractor for each Milestone as described in Section B2.1.1 (Payment Procedures) of Appendix B2.

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
1. System design					**100%**	**$**43,233,884
1	**1**	**MM**	**Submittal of Interim Project Schedule**	**15**	**5%**	**$2,161,694**
1	**2**	**MM**	**Completion of all Work necessary for approval of Conceptual Design**	**30**	**10%**	**$4,323,388**
1	**3**	**MM**	**Submittal of Project Management Plan**	**30**	**10%**	**$4,323,388**
1	4		Submittal of Project Schedule	90	10%	$4,323,388
1	**5**	**MM**	**Completion of all Work necessary for approval of Preliminary Design**	**231**	**15%**	**$6,485,083**
1	**6**	**MM**	**Completion of all Work necessary for approval of Final System Design**	**497**	**30%**	**$12,970,165**
1	7		First Article Configuration Inspection	903	20%	$8,646,777
2. Central Equipment, simulators, tools, documentation, and training					**100%**	$18,025,207
2	**1**	**MM**	**Delivery of all primary Central Control Equipment**	**917**	**25%**	**$4,506,302**

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
2	**2**	**MM**	**Delivery of all secondary Central Control Equipment**	**917**	**25%**	**$4,506,302**
2	3		Delivery of all simulators	1037	15%	$2,703,781
2	**4**	**MM**	**Delivery of initial operations and maintenance training (Pilot Phase)**	**1281**	**5%**	**$901,260**
2	5		Delivery of follow-up operations and maintenance training (Subway Replacement Phase)	1862	10%	$1,802,521
2	6		Delivery of final operations and maintenance training (Entire System)	3296	10%	$1,802,521
2	7		Delivery of all SLMDs and tools necessary for maintenance	1043	10%	$1,802,521
3. Onboard Equipment fitting					**100%**	$18,127,571
3	1		Successful static test of first equipped train in the test track	799	20%	$3,625,514
3	**2**	**MM**	**Completion of all Work necessary for SFMTA Acceptance of first 20 cars**	**1167**	**10%**	**$1,812,757**
3	3		Delivery of all Equipment and Materials necessary for all 219 cars	1651	30%	$5,438,271
3	4		Completion of all Work necessary for SFMTA Acceptance of all 219 cars	1862	30%	$5,438,271
3	5		Successful operation of historic and non-revenue vehicles on the CBTC System	1862	10%	$1,812,757
4. Pilot phase					**100%**	$23,447,108
4	**1**	**MM**	**Completion of all Work necessary for approval of Pilot Phase Construction Final Design**	**672**	**10%**	**$2,344,711**
4	2		Pilot FAT completed successfully	1055	10%	$2,344,711
4	3		All Pilot Phase Equipment delivered	896	10%	$2,344,711

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
4	4		All Pilot Phase static site acceptance tests completed	1139	10%	$2,344,711
4	**5**	**MM**	**All Pilot Phase dynamic site acceptance tests completed**	**1253**	**10%**	**$2,344,711**
4	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin Pilot Revenue Service**	**1281**	**30%**	**$7,034,132**
4	7		Completion of all Work identified in the Pilot Comment Period	1862	15%	$3,517,066
4	**8**	**MM**	**Completion of all Work necessary for Pilot Conditional Acceptance (following successful completion of Warranty Period)**	**2407**	**5%**	**$1,172,355**
5. Subway Replacement*					**100%**	$17,303,349
5	**1**	**MM**	**Completion of all Work necessary for approval of Subway Replacement Phase Construction Final Design**	**966**	**10%**	**$1,730,335**
5	2		Subway Replacement FAT completed successfully	1485	10%	$1,730,335
5	3		All Subway Replacement Phase Equipment delivered	1276	10%	$1,730,335
5	4		All Subway Replacement Phase static site acceptance tests completed	1541	10%	$1,730,335
5	**5**	**MM**	**All Subway Replacement Phase dynamic site acceptance tests completed**	**1834**	**10%**	**$1,730,335**
5	**6**	**MM**	**SFMTA approval to begin Subway Revenue Service (Subway Cutover)**	**1862**	**25%**	**$4,325,837**
5	**7**	**MM**	**Completion of all Work necessary for Subway Conditional Acceptance**	**2407**	**20%**	**$3,460,670**

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
			(following successful completion of Warranty Period)			
5	8		Successful removal of all legacy ATCS equipment from vehicles	1818	5%	$865,167
6. N Expansion*					**100%**	$7,484,939
6	**1**	**MM**	**Completion of all Work necessary for approval of N Expansion Phase Construction Final Design**	**1204**	**20%**	**$1,496,988**
6	2		N Expansion Replacement FAT completed successfully	1821	10%	$748,494
6	3		All N Expansion Phase Equipment delivered	1542	15%	$1,122,741
6	4		All N Expansion Phase static site acceptance tests completed	1877	10%	$748,494
6	5		All N Expansion Phase dynamic site acceptance tests completed	2002	15%	$1,122,741
6	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin N expansion Revenue Service**	**2030**	**10%**	**$748,494**
6	**7**	**MM**	**Completion of all Work necessary for N Expansion Conditional Acceptance**	**2575**	**20%**	**$1,496,988**
7. T Expansion*					**100%**	$7,391,297
7	**1**	**MM**	**Completion of all Work necessary for approval of T Expansion Phase Construction Final Design**	**1456**	**20%**	**$1,478,259**
7	2		T Expansion FAT completed successfully	1821	10%	$739,130
7	3		All T Expansion Phase Equipment delivered	1864	15%	$1,108,695

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
7	4		All T Expansion Phase static site acceptance tests completed	2030	10%	$739,130
7	5		All T Expansion Phase dynamic site acceptance tests completed	2142	15%	$1,108,695
7	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin T expansion Revenue Service**	**2198**	**10%**	**$739,130**
7	**7**	**MM**	**Completion of all Work necessary for T Expansion Conditional Acceptance**	**2743**	**20%**	**$1,478,259**
8. K&M Expansions*					**100%**	$8,254,099
8	**1**	**MM**	**Completion of all Work necessary for approval of K&M Expansion Phase Construction Final Design**	**1708**	**20%**	**$1,650,820**
8	2		K&M Expansion FAT completed successfully	2114	10%	$825,410
8	3		All K&M Expansion Phase Equipment delivered	2018	15%	$1,238,115
8	4		All K&M Expansion Phase static site acceptance tests completed	2198	10%	$825,410
8	5		All K&M Expansion Phase dynamic site acceptance tests completed	2331	15%	$1,238,115
8	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin K&M expansion Revenue Service**	**2366**	**10%**	**$825,410**
8	**7**	**MM**	**Completion of all Work necessary for K&M Expansion Conditional Acceptance**	**2911**	**20%**	**$1,650,820**
9. J Expansion*					**100%**	$3,931,892

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
9	**1**	**MM**	**Completion of all Work necessary for approval of J Expansion Phase Construction Final Design**	**1960**	**20%**	**$786,378**
9	2		J Expansion FAT completed successfully	2282	10%	$393,189
9	3		All J Expansion Phase Equipment delivered	2228	15%	$589,784
9	4		All J Expansion Phase static site acceptance tests completed	2359	10%	$393,189
9	5		All J Expansion Phase dynamic site acceptance tests completed	2499	15%	$589,784
9	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin J expansion Revenue Service**	**2534**	**10%**	**$393,189**
9	**7**	**MM**	**Completion of all Work necessary for J Expansion Conditional Acceptance**	**3079**	**20%**	**$786,378**
10. L Expansion*					**100%**	$4,315,089
10	**1**	**MM**	**Completion of all Work necessary for approval of L Expansion Phase Construction Final Design**	**2212**	**20%**	**$863,018**
10	2		L Expansion FAT completed successfully	2527	10%	$431,509
10	3		All L Expansion Phase Equipment delivered	2452	15%	$647,263
10	4		All L Expansion Phase static site acceptance tests completed	2583	10%	$431,509
10	5		All L Expansion Phase dynamic site acceptance tests completed	2709	15%	$647,263
10	**6**	**MM**	**Completion of all Work necessary for SFMTA approval to begin L expansion Revenue Service**	**2751**	**10%**	**$431,509**

Phase	No	MM	Milestone	Days From NTP	% of Phase Price	Milestone Payment
10	**7**	**MM**	**Completion of all Work necessary for L Expansion Conditional Acceptance**	**3296**	**20%**	**$863,018**

Appendix D
Contract Schedule

The Contract Schedule that is agreed to by the Parties will be provided as a separate file.

Appendix E

CONTRACT CHANGES

E1. GENERAL REQUIREMENTS

E1.1 The procedures and requirements set forth in this Appendix E are intended to ensure that when changes to the Work, in Contract Time or Contract Amount are proposed or rendered necessary in accordance with the Agreement, the Contractor and SFMTA will timely confer as to the need, purpose and requirements of the Change, so that the Contractor will provide the SFMTA with its best estimate of the costs and impacts associated with the proposed changed Work and the SFMTA may evaluate the proposed Change and proceed on an informed basis. These requirements and procedures are also intended to facilitate payment to the Contractor of additional, undisputed compensation for Contractor's performance of changed Work.

E1.2 The provisions of this Appendix E clarify but are subordinate to Article 4 of the Agreement, Financial Matters and 12.5 Contract Modifications and Change Orders. Contractor shall conform its Project Management Plan to the requirements and procedures set out in this Appendix E.

E1.3 Contractor and the SFMTA will confer on the status of outstanding Contractor Requests for Information (RFIs), SFMTA Clarifications, Requests for Contract Change (RCCs) from Contractor, and SFMTA Proposed Contract Changes (PCCs), as stated in the Project Management Plan.

E1.4 Failure by the Contractor to comply with the procedures of this Appendix E may constitute a waiver of any subsequent claim by the Contractor arising out of such Change Order, if the SFMTA determines that Contractor's failure to submit a timely RCC or meet other change process requirement has denied the SFMTA timely information or opportunity to timely consider alternatives or mitigations, or has otherwise prejudiced the SFMTA's interests.

E1.5 Contractor shall maintain its records in such a manner as to provide a clear distinction between the direct and indirect costs of Work under Changes and Change Orders and the direct and indirect costs of original Contract Work. This requirement pertains to all types of Changes and Change Orders, as well as the additions, deletions, revisions, RCCs, PCCs, and claims initiated by Contractor.

E2. REQUESTS FOR INFORMATION AND CLARIFICATIONS

E2.1 Should Contractor believe there is a contradiction, error, omission, or other problem in the Contract Documents, or should Contractor have a question as to the meaning or intent of any provision of the Contract Documents, or should the

SFMTA's comments on submittals returned to Contractor appear to Contractor to change the requirements or scope of the Work, Contractor shall promptly submit a Request for Information ("RFI") to the SFMTA requesting clarification, direction, or a Change. Contractor shall coordinate and schedule its Work to provide the SFMTA sufficient time (as provided in Section E2.2 below) to confer with Contractor and issue a written reply to the RFI before Contractor proceeds with the Work at issue.

E2.2 The SFMTA will issue a reply to a RFI within 15 Days of receipt of the RFI. The reply may include a written Clarification or a Proposed Contract Change. If the SFMTA needs additional time to issue a reply, the SFMTA will notify the Contractor of the time it will require, but in no event shall the time SFMTA needs to respond exceed thirty (30) Days.

E2.3 A Clarification is binding on Contractor, and Contractor shall perform the Work as described in the Clarification. A Clarification is not a Change Order and does not entitle Contractor to a modification of the Contract Amount or a change in the Contract Time. If Contractor believes that a Clarification increases the costs of the Work or impacts a Milestone completion date or the Project final completion date, Contractor may submit a Request for Contract Change (RCC).

E3. CONTRACTOR REQUESTS FOR CONTRACT CHANGE (RCCs)

E3.1 Request for Contract Change. If the Contractor seeks additional compensation or extension of time due to the directives of a Clarification, or for any other purpose, Contractor shall submit to the SFMTA Project Manager a Request for Contract Change (RCC) within ten Days of the date of the Clarification or the date of Notice of Delay confirmation after Contractor first becomes aware of the additional cost or extended time caused by a problem in the Contract Documents or by an Unavoidable Delay (See section 5.18.3).

E3.2 RCC Contents. An RCC shall reference relevant Contract Specifications, and shall include a detailed explanation of the basis for Contractor’s request and a cost and time proposal as required by Section E5.1 below. Contractor shall provide the SFMTA Project Manager any relevant information that the SFMTA requests so that the SFMTA Project Manager may better understand the scope and reason for the RCC. Contractor shall not submit an RCC on any issue without first submitting an RFI, unless the SFMTA authorizes Contractor to submit an RCC without first submitting an RFI. For clarity, an RCC due to an Unavoidable Delay shall not be subject to the prior submission of an RFI.

E4. SFMTA PROPOSED CONTRACT CHANGES (PCCs)

E4.1 PCC Initiation. The SFMTA may, at any time between the Notice to Proceed and the end of the Support Term, and without notice to Contractor's surety, order additions, deletions, or revisions in the Work within the general scope of the

Contract Documents by negotiated bilateral Contract Modification or Unilateral Contract Modification in accordance with Agreement Section 12.5 and this Appendix E. The SFMTA will initiate a Contract Modification by issuing a Proposed Contract Change (PCC). A PCC will include a detailed description of the proposed additions, deletions or revisions to the Work, which may include supplementary or revised Drawings and Specifications, and will request from Contractor a quotation of cost and time, and a description of the Contractor's approach for completing the proposed changes to the Work.

E4.2 PCC Proposal. Contractor shall submit a PCC Proposal (meeting the requirements stated in Section E5.1 below) to the SFMTA Project Manager within 10 Days of receipt of a PCC. Contractor may request additional time as long as such request is made within 10 Days of the date of the PCC.

E5. PROCESSING OF RCCs AND PCC PROPOSALs

E5.1 Proposal Requirements. RCCs and PCC Proposals shall include cost proposals containing a complete itemized breakdown of all labor, Material, Equipment, profit, overhead and any other costs to perform the changed Work consistent with the cost categories set out in Appendices B and G and accounted as required under federal Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, set out in 2 CFR §§ 200.400-476 (Cost Principals). RCCs and PCC Proposals shall also include a time impact analysis showing the impact of the change Work on Milestone completion dates and the Project completion date.

E5.2 Meet and Confer. The SFMTA Project Manager and will meet and confer with Contractor to discuss RCCs and PCC Proposals within 15 Days of their receipt.

E5.3 Draft Determination. The SFMTA Project Manager will provide Contractor a draft written determination in accordance with Section 12.7 within 30 Days after receipt of an RCC or a PCC Proposal, in order to give Contractor the opportunity to respond with comments and proposed changes.

E5.4 Final Determination.

E5.4.1 If the Contractor provides a written response within fifteen (15) Days after receipt of the draft determination, the SFMTA Project Manager will issue a final written determination that addresses Contractor's response no later than fifteen (15) Days after receipt of Contractor's responses, unless both parties agree in writing to a different due date for the final written determination.

E5.4.2 Subject to any alternative due date agreed upon between the Parties, if the Contractor does not provide a response within ten Days after receipt of the draft determination, the draft determination will become final.

E5.5 Claim.

E5.5.1 If the final determination rejects a RCC or PCC Proposal in whole or in part, Contractor may contest that decision by filing a timely written claim per Section 12.6 of the Agreement (Contract Claim Requirements).

E5.5.2 For a RCC, if the SFMTA Project Manager does not issue a draft written determination within the time described in section E5.3, the RCC may be deemed rejected and Contractor may pursue a claim under Section 12.6 of the Agreement.

E6. BILATERAL CONTRACT MODIFICATIONS

E6.1 Execution of Contract Modifications. When the SFMTA and Contractor agree on the total cost and time in a final determination of an RCC or a PCC Proposal, the SFMTA will include the agreement in a bilateral Contract Modification implementing the change. No oral instructions of any person whomsoever shall in any manner or degree can modify or otherwise affect the terms of the Contract. Contract Modifications that result in an increase to the Contract Amount or Contract Time must be approved in accordance with SFMTA policies and City Charter section 9.118. (See also General Provisions, Sections 4.1 to 4.3).

E6.2 Release of Claims. The parties agree to make good faith efforts to resolve all issues and disputes concerning cost and time impacts when the parties execute a bilateral Contract Modification. Accordingly, bilateral Contract Modifications shall contain the following provision (unless both parties agree to use different release language for a specific Contract Modification):

The compensation and any time extension provided in this Modification comprises the total compensation and time extension due to Contractor, all Affiliates, Subcontractors and all Suppliers, for the changed Work described in this Modification, including any impact on unchanged Work and Ancillary Work necessary to perform the changed Work. By executing this Modification, Contractor acknowledges and agrees on behalf of itself, all Affiliates, Subcontractors, and all Suppliers, that the stated time extension and compensation includes all time extension and all compensation owed for all Work described in the Modification, plus all time extension and compensation owed for the interruption of schedules, extended field and home overhead costs, delay, and all impact, ripple effect or cumulative impact on all other Work. The parties' execution of this Modification indicates that the Modification constitutes full mutual accord and satisfaction of all costs and impacts arising from or related to the changed Work. The Contractor, on behalf of itself, all Affiliates, Subcontractors, and all Suppliers, waives all rights, without exception or reservation of any kind whatsoever in law or equity, to seek or receive further compensation or time extension related to this Work described in this Modification."

E6.3 A Contract Modification shall not in any way release any of Contractor's obligations, guarantees or warranties under the Contract, nor shall they relieve or release Contractor's sureties of bond obligations issued for this Contract. The sureties, in executing such bonds, shall be deemed to have expressly agreed to any such Contract Modifications and to any extension of Contract Time and increase in Contract Amount effected by any Contract Modification. Contractor shall be responsible for informing its surety of any change affecting the Work, Contract Amount or Contract Time that is required by the provisions of any bond.

E7. UNILATERAL CHANGE ORDERS

E7.1 General. If Contractor fails to submit a PCC Proposal within the period referenced in Section E.4.2, or if the SFMTA Project Manager determines that: (1) the Parties cannot agree on a price or time adjustment for the Additional Work described in the PCC Proposal; or (2) the urgency of the Additional Work does not allow time for the parties to negotiate a bilateral Contract Modification, the SFMTA Project Manager may direct Contractor to proceed with the Changes under a unilateral Contract Modification instructing Contractor to proceed with the Changes based on the SFMTA's estimate of the cost and/or time impact of the Changes. A unilateral Contract Modification will be issued under section 12.5 of the Agreement (Contract Modifications and Change Orders) and will be binding on Contractor, and Contractor shall perform the Work as specified in the unilateral Contract Modification.

E7.2 Limitations on Unilateral Contract Modifications. Unilateral Contract Modifications will include a not-to-exceed price and requirements for timely reporting of Contractor's costs incurred on Work included in the Contract Modification. The Contractor will not be required to continue the Work after it has incurred costs in the not-to-exceed amount. In no event will the total price of the unilateral Contract Modification be greater than the amount of the contracting authority delegated to the SFMTA official that signs the modification.

E7.3 Claim. If Contractor disagrees with any terms or conditions of a unilateral Contract Modification, Contractor may, within 30 Days of receipt of the unilateral Contract Modification, submit a claim under Agreement Section 12.6.

Appendix F

Performance Bonds

Appendix F1
PROCUREMENT TERM PERFORMANCE BOND

KNOW ALL MEN BY THESE PRESENTS, that WHEREAS, the City and County of San Francisco, State of California, has awarded to:

_____

hereinafter designated as the "Principal", a contract, dated, _____, for the City and County of San Francisco's Office of Contract Administration Contract No. _____ (the "Contract").

WHEREAS, said Principal is required under clause 5.19 of the Contract to furnish to the City and County of San Francisco ("City") a bond for the faithful performance of the Contract before Final Acceptance of the Procurement Term portion of the Contract (the "Procurement Term Performance Bond") in an amount of not less than 100% of the Total System Procurement Price;

WHEREAS, under clause 5.19.1 of the Contract, the Procurement Term Performance Bond shall terminate automatically upon Final Acceptance, and shall be released by the City.

NOW, THEREFORE, we the Principal and _____, as Surety, are firmly bound unto the City in the penal sum of

_____ Dollars ($_____)

lawful money of the United States for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally firmly by these presents for a Procurement Term Performance Bond. The condition of this obligation is such that if the said Principal does well and faithfully perform all the conditions and covenants of the Contract before Final Acceptance of the Procurement portion of the Contract, according to the true intent and meaning thereof, upon its part to be kept and performed, then the above obligation is to be null and void, otherwise to remain in full force and effect.

THE CONDITION OF THIS OBLIGATION IS SUCH, that if the above bounden Principal, its heirs, executors, administrators, successors or assigns, shall in all things stand to and abide by, and well and truly keep and perform the covenants, conditions and agreements of the Procurement Term portion of the Contract before Final Acceptance, including the provisions for liquidated damages in the said Contract, any changes, additions or alterations thereof made as therein provided, on its part, to be kept and performed at the time and in the manner therein specified, and in all respects according to their true intent and meaning, and shall indemnify and save harmless the City, its officers and agents, as therein stipulated, then this obligation shall become null and void; otherwise it shall be and remain in full force and effect.

And the said Surety, for value received, hereby stipulates and agrees that no change, extension of time, alteration or addition to the Procurement Term of the Contract or to the Procurement Term work to be performed thereunder or the specifications accompanying the same and no inadvertent overpayment of progress payments shall in any way affect its obligations on this Procurement Term Performance Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the Contract or to the work or to the specifications or of any inadvertent overpayment of progress payments.

Unless the City has materially breached the Contract, the Surety's obligation under this Procurement Term Performance Bond shall arise after the City first provides notice to the Contractor and the Surety that an Event of Default has occurred under section 9.2 of the Contract and has agreed to pay the Balance of the Contract Price in accordance with the terms of the Contract to the Surety or another party at the direction of the Surety. Subsequent to receipt of such notice of the Event of Default, Surety shall make determination as to how it will proceed and advise City accordingly.

For the sake of clarity, the Balance of the Contract Price means the total amount payable by the City to the Contractor under the Contract after all proper adjustments have been made pursuant to the Contract, reduced by all valid and proper payments made to or on behalf of the Contractor under the Contract.

The penal sum of this Procurement Term Performance Bond shall be reduced by and to the extent of any payment or payments made by the Surety under this Procurement Term Performance Bond.

In no event shall the Surety's aggregate liability exceed the penal sum of this Procurement Term Performance Bond.

The Surety's shall have no obligation to provide the Support Term Performance Bond required under section 5.19.2 of the Contract, and the failure of the Principal to provide any Support Term Performance Bond shall not constitute a breach or default by the Surety under the terms of this Procurement Term Performance Bond or give rise to any claim or cause of action against the Surety under the terms of this Procurement Term Performance Bond.

If there is any conflict between the terms and conditions of the Procurement Term Performance Bond and the Contract, then the terms and conditions of the Procurement Term Performance Bond shall govern.

IN WITNESS WHEREOF, the above-bounden parties have executed this instrument under their seal this _____day of _____, 20_____, the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

PRINCIPAL

By: _____

Its: _____

Date: _____

SURETY

By: _____

Its: _____

Date: _____

_____

NOTE: Signature of Sureties must be acknowledged by a Notary Public

CITY

By: _____
[INSERT NAME], Controller

Date: _____

Approved as to form:
David Chiu
City Attorney

By: _____
[INSERT NAME]
Deputy City Attorney

Appendix F2

SUPPORT TERM PERFORMANCE BOND

KNOW ALL MEN BY THESE PRESENTS, that WHEREAS, the City and County of San Francisco, State of California, has awarded to:

_____

hereinafter designated as the "Principal", a contract, dated, _____, for the City and County of San Francisco's Office of Contract Administration Contract No. _____ (the "Contract").

WHEREAS, said Principal is required under clause 5.19.2 of the Contract to furnish to the City and County of San Francisco ("City"), 30 days before Final Acceptance of the Procurement Term portion of the Contract, a bond for the faithful performance of the Contract after Final Acceptance of the Procurement Term portion of the Contract (the "Support Term Performance Bond") in an amount of not less than 30% of the base 10 year Total Support Fee;

WHEREAS, this Support Term Performance Bond shall be effective on the date of Final Acceptance of the Procurement Term portion of the Contract and release of the Procurement Term Performance Bond (the "Effective Date").

WHEREAS, the term of this Support Term Performance Bond shall be a for period of five years which at the sole option and discretion of the Surety may renewed or otherwise extended.

NOW, THEREFORE, we the Principal and _____, as Surety, are firmly bound unto the City in the penal sum of
_____ Dollars ($_____)

lawful money of the United States for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally firmly by these presents for a Support Term Performance Bond from the Effective Date for a term of five years. The condition of this obligation is such that if the said Principal does well and faithfully perform all the conditions and covenants of the Support Term portion the Contract during the five year term of this

Support Term Performance Bond, according to the true intent and meaning thereof, upon its part to be kept and performed, then the above obligation is to be null and void, otherwise to remain in full force and effect.

THE CONDITION OF THIS OBLIGATION IS SUCH, that if the above bounden Principal, its heirs, executors, administrators, successors or assigns, shall in all things stand to and abide by, and well and truly keep and perform the covenants, conditions and agreements of the Support Term portion of the Contract after Final Acceptance within the initial five (5) year term of this Support Term Performance Bond, and during any successive five year term in which this Support Term Performance Bond is renewed or otherwise extended, at the Surety's sole discretion, including the provisions for liquidated damages in the said Contract, any changes, additions or alterations thereof made as therein provided, on its part, to be kept and performed at the time and in the manner therein specified, and in all respects according to their true intent and meaning, and shall indemnify and save harmless the City, its officers and agents, as therein stipulated, then this obligation shall become null and void; otherwise it shall be and remain in full force and effect during the initial five (5) year term, and during any renewals or extensions that have been made at the Surety's sole discretion. For the avoidance of doubt, the Surety's obligations under this Support Term Performance Bond shall only apply to the Support Term obligations from the Effective Date of this Support Term Performance Bond.

And the said Surety, for value received, hereby stipulates and agrees that no change, extension of time, alteration or addition to the Support Term of the Contract or to the Support Term work to be performed thereunder or the specifications accompanying the same and no inadvertent overpayment of progress payments shall in any way affect its obligations on this Support Term Performance Bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the Contract or to the work or to the specifications or of any inadvertent overpayment of progress payments.

Unless the City has materially breached the Contract, the Surety's obligation under this Support Term Performance Bond shall arise after the City first provides notice to the Contractor and the Surety that an event of Default has occurred under section 9.2 of the Agreement and has agreed to pay the Support Fee relating to these obligations in accordance with the terms of the Contract to the Surety or another party at the direction of the Surety. Subsequent to receipt of such notice of the Event of Default, Surety shall make determination as to how it will proceed and advise City accordingly.

In no event shall the Surety's aggregate liability exceed the penal sum of this Support Term Performance Bond.

The penal sum of this Support Term Performance Bond shall be reduced by and to the extent of any payment or payments made by the Surety under this Support Term Performance Bond.

If there is any conflict between the terms and conditions of the Support Term Performance Bond and the Contract, then the terms and conditions of the Support Term Performance Bond shall govern.

This Support Term Performance Bond shall be for the initial term of five (5) years and may be renewed or otherwise extended at the Surety's sole discretion for up to three additional successive five (5) year terms by rider or continuation certificate to the existing Support Term Performance Bond. The Surety has the option, in its sole discretion, whether to renew or otherwise extend the Support Term Performance Bond. The Surety's failure or refusal to renew or extend the term of this Support Term Performance Bond at any time shall not constitute a breach or default by the Surety under the terms of this Support Term Performance Bond or give rise to any claim or cause of action against the Surety under the terms of this Support Term Performance Bond. Additionally, the Contractor's failure to secure replacement security shall not constitute a default under this Support Term Performance Bond or give rise to any claim or cause of action against the Surety under the terms of this Support Term Performance Bond.

IN WITNESS WHEREOF, the above-bounden parties have executed this instrument under their seal this _____ day of _____, 20_____, the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

PRINCIPAL

By: _____

Its: _____

Date: _____

SURETY

By: _____ _____

Its: _____

Date: _____

NOTE: Signature of Sureties must be acknowledged by a Notary Public

CITY

By: _____
[INSERT NAME], Controller

Date: _____

Approved as to form:
David Chiu
City Attorney

By: _____
[INSERT NAME]
Deputy City Attorney

Appendix G

Federal Contract Requirements

I. DEFINITIONS

A. Approved Project Budget means the most recent statement, approved by the FTA, of the costs of the Project, the maximum amount of Federal assistance for which the City is currently eligible, the specific tasks (including specified contingencies) covered, and the estimated cost of each task.

B. Contractor means the individual or entity awarded a third-party contract financed in whole or in part with Federal assistance originally derived from FTA.

C. Cooperative Agreement means the instrument by which FTA awards Federal assistance to a specific Recipient to support a particular Project or Program, and in which FTA takes an active role or retains substantial control.

D. Federal Transit Administration (FTA) is an operating administration of the U.S. DOT.

E. FTA Directive includes any FTA circular, notice, order or guidance providing information about FTA's programs, application processing procedures, and Project management guidelines. In addition to FTA directives, certain U.S. DOT directives also apply to the Project.

F. Grant Agreement means the instrument by which FTA awards Federal assistance to a specific Recipient to support a particular Project, and in which FTA does not take an active role or retain substantial control, in accordance with 31 U.S.C. § 6304.

G. Government means the United States of America and any executive department or agency thereof.

H. Project means the task or set of tasks listed in the Approved Project Budget, and any modifications stated in the Conditions to the Grant Agreement or Cooperative Agreement applicable to the Project. In the case of the formula assistance program for urbanized areas, for elderly and persons with disabilities, and non-urbanized areas, 49 U.S.C. §§ 5307, 5310, and 5311, respectively, the term "Project" encompasses both "Program" and "each Project within the Program," as the context may require, to effectuate the requirements of the Grant Agreement or Cooperative Agreement.

I. Recipient means any entity that receives Federal assistance directly from FTA to accomplish the Project. The term "Recipient" includes each FTA "Grantee" as well

as each FTA Recipient of a Cooperative Agreement. For the purpose of this Agreement, Recipient is the City.

J. Secretary means the U.S. DOT Secretary, including his or her duly authorized designee.

K. Third Party Contract means a contract or purchase order awarded by the Recipient to a vendor or contractor, financed in whole or in part with Federal assistance awarded by FTA.

L. Third Party Subcontract means a subcontract at any tier entered into by Contractor or third party subcontractor, financed in whole or in part with Federal assistance originally derived from FTA.

M. U.S. DOT is the acronym for the U.S. Department of Transportation, including its operating administrations.

II. FEDERAL CHANGES

Contractor shall at all times comply with all applicable FTA regulations, policies, procedures and directives, including without limitation those listed directly or by reference in the Master Agreement between the City and FTA, as they may be amended or promulgated from time to time during the term of this contract. Contractor's failure to so comply shall constitute a material breach of this contract.

III. ACCESS TO RECORDS

A. The Contractor agrees to provide the City and County of San Francisco, the FTA Administrator, the Comptroller General of the United States or any of their authorized representatives access to any books, documents, papers and records of the Contractor which are directly pertinent to this Agreement for the purposes of making audits, examinations, excerpts and transcriptions.

B. The Contractor agrees to permit any of the foregoing parties to reproduce by any means whatsoever or to copy excerpts and transcriptions as reasonably needed.

C. The Contractor agrees to maintain all books, records, accounts and reports required under this Agreement for a period of not less than three years after the date of termination or expiration of this Agreement, except in the event of litigation or settlement of claims arising from the performance of this Agreement, in which case Contractor agrees to maintain same until the City, the FTA Administrator, the Comptroller General, or any of their duly authorized representatives, have disposed of all such litigation, appeals, claims or exceptions related thereto. 49 CFR 18.36(i)(11).

IV. DEBARMENT AND SUSPENSION

A. The Contractor shall comply and facilitate compliance with U.S. DOT regulations, "Nonprocurement Suspension and Debarment," 2 C.F.R. part 1200, which adopts and supplements the U.S. Office of Management and Budget (U.S. OMB) "Guidelines to Agencies on Governmentwide Debarment and Suspension (Nonprocurement)," 2 C.F.R. part 180. These provisions apply to each contract at any tier of $25,000 or more, and to each contract at any tier for a federally required audit (irrespective of the contract amount), and to each contract at any tier that must be approved by an FTA official irrespective of the contract amount. As such, the Contractor shall verify that its principals, affiliates, and subcontractors are eligible to participate in this federally funded contract and are not presently declared by any Federal department or agency to be:

a) Debarred from participation in any federally assisted Award;
b) Suspended from participation in any federally assisted Award;
c) Proposed for debarment from participation in any federally assisted Award;
d) Declared ineligible to participate in any federally assisted Award;
e) Voluntarily excluded from participation in any federally assisted Award; or
f) Disqualified from participation in any federally assisted Award.

See Appendix D, Certification Regarding Debarment, Suspension, and Other Responsibility Matters.

B. The Contractor agrees to include a provision in its lower-tier covered transactions requiring lower-tier participants to comply with the requirements of 2 CFR Part 180, Subpart C, and Part 1200, Subpart C.

V. NO FEDERAL GOVERNMENT OBLIGATIONS TO CONTRACTOR

A. The City and Contractor acknowledge and agree that, notwithstanding any concurrence by the Federal Government in or approval of the solicitation or award of the underlying contract, absent the express written consent by the Federal Government, the Federal Government is not a party to this contract and shall not be subject to any obligations or liabilities to the City, Contractor, or any other party (whether or not a party to that contract) pertaining to any matter resulting from the underlying contract.

B. The Contractor agrees to include the above clause in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clause shall not be modified, except to identify the subcontractor who will be subject to its provisions.

VI. CIVIL RIGHTS

A. Nondiscrimination – In accordance with Title VI of the Civil Rights Act, as amended, 42 U.S.C. § 2000d, section 303 of the Age Discrimination Act of 1975, as amended, 42 U.S.C. § 6102, section 202 of the Americans with Disabilities Act of 1990, 41 U.S.C. § 12132, and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees that it will not discriminate against any employee or applicant for employment because of race, color, creed, national origin, sex, age, or disability. In addition, the Contractor agrees to comply with applicable Federal implementing regulations and other implementing requirements FTA may issue.

B. Equal Employment Opportunity – The following equal employment opportunity requirements apply to the underlying contract:

1.Race, Color, Creed, National Origin, Sex – In accordance with Title VII of the Civil Rights Act, as amended, 42 U.S.C. § 2000e, and Federal transit laws at 49 U.S.C. § 5332, the Contractor agrees to comply with all applicable equal employment opportunity requirements of U.S. Department of Labor (U.S. DOT) regulations, "Office of Federal Contract Compliance Programs, Equal Employment Opportunity, Department of Labor," 41 CFR Parts 60 et seq., (which implement Executive Order No. 11246, "Equal Employment Opportunity," as amended by Executive Order No. 11375, "Amending Executive Order 11246 Relating to Equal Employment Opportunity," 42 U.S.C. § 2000e note), and with any applicable Federal statutes, executive orders, regulations, and Federal policies that may in the future affect construction activities undertaken in the course of the Project. The Contractor agrees to take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, creed, national origin, sex, or age. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer, recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

2.Age – In accordance with section 4 of the Age Discrimination in Employment Act of 1967, as amended, 29 U.S.C. § 623 and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees to refrain from discrimination against present and prospective employees for reason of age. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

3.Disabilities – In accordance with section 102 of the Americans with Disabilities Act, as amended, 42 U.S.C. § 12112, the Contractor agrees that it will comply with the requirements of U.S. Equal Employment Opportunity Commission, "Regulations to Implement the Equal Employment Provisions of the Americans

with Disabilities Act," 29 CFR Part 1630, pertaining to employment of persons with disabilities. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

C. The Contractor also agrees to include these requirements in each subcontract financed in whole or in part with Federal assistance provided by FTA, modified only if necessary to identify the affected parties.

VII. DBE/SBE ASSURANCES

Pursuant to 49 C.F.R. Section 26.13, the Contractor is required to make the following assurance in its agreement with SFMTA and to include this assurance in any agreements it makes with subcontractors in the performance of this contract:

> The Contractor or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The Contractor shall carry out applicable requirements of 49 C.F.R. Part 26 in the award and administration of DOT-assisted contracts. Failure by the Contractor or Subcontractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as SFMTA deems appropriate.

VIII. PATENT RIGHTS *(applicable to contracts for experimental, research, or development projects financed by FTA)*

A. General. If any invention, improvement, or discovery is conceived or first actually reduced to practice in the course of or under this Agreement, and that invention, improvement, or discovery is patentable under the laws of the United States of America or any foreign country, the City and Contractor agree to take actions necessary to provide immediate notice and a detailed report to the FTA.

B. Unless the Federal Government later makes a contrary determination in writing, irrespective of the Contractor's status (large business, small business, state government or instrumentality, local government, nonprofit organization, institution of higher education, individual), the City and Contractor agree to take the necessary actions to provide, through FTA, those rights in that invention due the Federal Government described in U.S. Department of Commerce regulations, "Rights to Inventions Made by Nonprofit Organizations and Small Business Firms Under Government Grants, Contracts and Cooperative Agreements," 37 CFR Part 401.

C. The Contractor also agrees to include the requirements of this clause in each subcontract for experimental, developmental, or research work financed in whole or in part with Federal assistance provided by FTA.

IX. RIGHTS IN DATA AND COPYRIGHTS *(Applicable to contracts for planning, research, or development financed by FTA)*

A. Definition. The term "subject data" used in this section means recorded information, whether or not copyrighted, that is delivered or specified to be delivered under this Agreement. The term includes graphic or pictorial delineation in media such as drawings or photographs; text in specifications or related performance or design-type documents; machine forms such as punched cards, magnetic tape, or computer memory printouts; and information retained in computer memory. Examples include, but are not limited to, computer software, engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identifications, and related information. The term "subject data" does not include financial reports, cost analyses, and similar information incidental to contract administration.

B. Federal Restrictions. The following restrictions apply to all subject data first produced in the performance of this Agreement.

1. Publication of Data. Except for its own internal use in conjunction with the Agreement, Contractor may not publish or reproduce subject data in whole or in part, or in any manner or form, nor may Contractor authorize others to do so, without the written consent of the Federal Government, until such time as the Federal Government may have either released or approved the release of such data to the public; this restriction on publication, however, does not apply to any contract with an academic institution.

2. Federal License. The Federal Government reserves a royalty-free, non-exclusive and irrevocable license to reproduce, publish or otherwise use, and to authorize others to use, "for Federal Government purposes," any subject data or copyright described below. As used in the previous sentence, "for Federal Government purposes" means use only for the direct purposes of the Federal Government. Without the copyright owner's consent, the Federal Government may not extend its Federal license to any other party:

a. Any subject data developed under this Agreement, whether or not a copyright has been obtained; and

b. Any rights of copyright purchased by City or Contractor using Federal assistance in whole or in part provided by FTA.

3. FTA Intention. When FTA awards Federal assistance for an experimental, research or developmental work, it is FTA's general intention to increase transportation knowledge available to the public, rather than to restrict the benefits resulting from the work to participants in the work. Therefore, unless

FTA determines otherwise, the Contractor performing experimental, research, or developmental work required by the underlying Agreement agrees to permit FTA to make available to the public, either FTA's license in the copyright to any subject data developed in the course of the Agreement, or a copy of the subject data first produced under the Agreement for which a copyright has not been obtained. If the experimental, research, or developmental work which is the subject of this Agreement is not completed for any reason whatsoever, all data developed under this Agreement shall become subject data as defined in Subsection a. above and shall be delivered as the Federal Government may direct. This subsection does not apply to adaptations of automatic data processing equipment or programs for the City's use the costs of which are financed with Federal transportation funds for capital projects.

4. **Hold Harmless**. Unless prohibited by state law, upon request by the Federal Government, the Contractor agrees to indemnify, save, and hold harmless the Federal Government, its officers, agents, and employees acting within the scope of their official duties, against any liability, including costs and expenses, resulting from any willful or intentional violation by the Contractor of proprietary rights, copyrights, or right of privacy, arising out of the publication, translation, reproduction, delivery, use, or disposition of any data furnished under this Agreement. The Contractor shall not be required to indemnify the Federal Government for any such liability arising out of the wrongful acts of employees or agents of the Federal Government.

5. **Restrictions on Access to Patent Rights**. Nothing contained in this section on rights in data shall imply a license to the Federal Government under any patent or be construed as affecting the scope of any license or other right otherwise granted to the Federal Government under any patent.

6. **Application to Data Incorporated into Work**. The requirements of Subsections (2), (3) and (4) of this Section do not apply to data developed by the City or Contractor and incorporated into the work carried out under this Agreement, provided that the City or Contractor identifies the data in writing at the time of delivery of the work.

7. **Application to Subcontractors**. Unless FTA determines otherwise, the Contractor agrees to include these requirements in each subcontract for experimental, developmental, or research work financed in whole or in part with Federal assistance provided by FTA.

C. Flow Down. The Contractor also agrees to include these requirements in each subcontract for experimental, developmental, or research work financed in whole or in part with Federal assistance provided by FTA.

D. Provision of Rights to Government. Unless the Federal Government later makes a contrary determination in writing, irrespective of the Contractor's status (large business, small business, state government or instrumentality, local government, nonprofit organization, institution of higher education, individual, etc.), the City and Contractor agree to take the necessary actions to provide, through FTA, those rights in that invention due the Federal Government described in U.S. Department of Commerce regulations, "Rights to Inventions Made by Nonprofit Organizations and Small Business Firms Under Government Grants, Contracts and Cooperative Agreements," 37 CFR Part 401.

X. CONTRACT WORK HOURS AND SAFETY STANDARDS *(applicable to nonconstruction contracts in excess of $100,000 that employ laborers or mechanics on a public work)*

A. Overtime requirements – No contractor or subcontractor contracting for any part of the contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay for all hours worked in excess of forty hours in such workweek.

B. Violation; liability for unpaid wages; liquidated damages – In the event of any violation of the clause set forth in paragraph A of this section the contractor and any subcontractor responsible therefor shall be liable for the unpaid wages. In addition, such contractor and subcontractor shall be liable to the United States for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the clause set forth in paragraph A of this section, in the sum of $10 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph A of this section.

C. Withholding for unpaid wages and liquidated damages – The City and County of San Francisco shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by the contractor or subcontractor under any such contract or any other Federal contract with the same prime contractor, or any other federally-assisted contract subject to the Contract Work Hours and Safety Standards Act, which is held by the same prime contractor, such sums as may be determined to be necessary to satisfy any

liabilities of such contractor or subcontractor for unpaid wages and liquidated damages as provided in the clause set forth in paragraph (2) of this section.

D. Subcontracts – The contractor or subcontractor shall insert in any subcontracts the clauses set forth in paragraphs A through D of this section and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime contractor shall be responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs A through D of this section.

XI. ENERGY CONSERVATION REQUIREMENTS

The Contractor agrees to comply with mandatory standards and policies relating to energy efficiency which are contained in the state energy conservation plan issued in compliance with the Energy Policy and Conservation Act.

XII. CLEAN WATER REQUIREMENTS *(applicable to all contracts in excess of $100,000)*

A. The Contractor agrees to comply with all applicable standards, orders, or regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. §§ 1251 et seq. Contractor agrees to report each violation of these requirements to the City and understands and agrees that the City will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA regional office.

B. The Contractor also agrees to include these requirements in each subcontract exceeding $100,000 financed in whole or in part with Federal assistance provided by FTA.

XIII. CLEAN AIR *(applicable to all contracts and subcontracts in excess of $100,000, including indefinite quantities where the amount is expected to exceed $100,000 in any year.)*

A. Contractor agrees to comply with applicable standards, orders, or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. §§ 7401 et seq. The Contractor agrees to report each violation to the City and understands and agrees that the City will, in turn, report each violation as required to assure notification to FTA and the appropriate EPA Regional Office.

B. The Contractor also agrees to include these requirements in each subcontract exceeding $100,000 financed in whole or in part with Federal assistance provided by FTA.

XIV. PRIVACY

If Contractor or its employees administer any system of records on behalf of the Federal Government, Contractor and its employees agree to comply with the information restrictions and other applicable requirements of the Privacy Act of 1974, 5 U.S.C. § 552a (the Privacy Act). Specifically, Contractor agrees to obtain the express consent of the Federal Government before the Contractor or its employees operate a system of records on behalf of the Government. Contractor acknowledges that the requirements of the Privacy Act, including the civil and criminal penalties for violations of the Privacy Act, apply to those individuals involved, and that failure to comply with the terms of the Privacy Act may result in termination of this Agreement. The Contractor also agrees to include these requirements in each subcontract to administer any system of records on behalf of the Federal Government financed in whole or in part with Federal assistance provided by FTA.

XV. DRUG AND ALCOHOL TESTING

To the extent Contractor, its subcontractors or their employees perform a safety-sensitive function under the Agreement, Contractor agrees to comply with, and assure compliance of its subcontractors, and their employees, with 49 U.S.C. § 5331, and FTA regulations, "Prevention of Alcohol Misuse and Prohibited Drug Use in Transit Operations," 49 CFR Part 655.

XVI. TERMINATION FOR CONVENIENCE OF CITY *(required for all contracts in excess of $10,000)*

See Agreement Terms and Conditions.

XVII. TERMINATION FOR DEFAULT *(required for all contracts in excess of $10,000)*

See Agreement Terms and Conditions.

XVIII. BUY AMERICA

The Contractor agrees to comply with 49 U.S.C. 5323(j) and 49 CFR Part 661, which provide that Federal funds may not be obligated unless steel, iron, manufactured products, and construction materials (*excluding* cement and cementitious materials, aggregates such as stone, sand, or gravel, or aggregate binding agents or additives) used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. "Construction materials" include an article, material, or supply that is or consists primarily of:

- Non-ferrous metals;
- Plastic and polymer-based products (including polyvinylchloride, composite building materials, and polymers used in fiber optic cables);

- Glass (including optic glass);
- Lumber; or
- Drywall.

General waivers are listed in 49 CFR 661.7, and include microcomputer equipment, software, and small purchases ($150,000 or less) made with capital, operating, or planning funds. Separate requirements for rolling stock are set out at 49 U.S.C. 5323(j)(2)(C) and 49 CFR 661.11. Rolling stock not subject to a general waiver must be manufactured in the United States and have a 70 percent domestic content.

XIX. PROHIBITION AGAINST USE OF CONTRACT FUNDS FOR COVERED TELECOMMUNICATIONS EQUIPMENT

Under 2 CFR Section 216, Contractors and Subcontractors are prohibited from using Contract funds to:

A. Procure or obtain;

B. Extend or renew a contract to procure or obtain; or

C. Enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As described in Section 889 of Public Law 115-232, covered telecommunications equipment is:

1. Telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities).

2. For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by Hytera Communications Corporation, Hangzhou Hikvision Digital Technology Company, or Dahua Technology Company (or any subsidiary or affiliate of such entities).

3. Telecommunications or video surveillance services provided by such entities or using such equipment.

4. Telecommunications or video surveillance equipment or services produced or provided by an entity that the Secretary of Defense, in consultation with the Director of the National Intelligence or the Director of the Federal Bureau of Investigation, reasonably believes to be an entity owned or controlled by, or otherwise connected to, the government of a covered foreign country.

XX. CARGO PREFERENCE - USE OF UNITED STATES FLAG VESSELS

The Contractor agrees: (a) to use privately owned United States-Flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved, whenever shipping any equipment, material, or commodities pursuant to the underlying Agreement to the extent such vessels are available at fair and reasonable rates for United States-Flag commercial vessels; (b) to furnish within 20 working days following the date of loading for shipments originating within the United States or within 30 working days following the date of leading for shipments originating outside the United States, a legible copy of a rated, "on-board" commercial ocean bill-of-lading in English for each shipment of cargo described above to the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, DC 20590 and to the FTA recipient (through the Contractor in the case of a subcontractor's bill-of-lading.); and (c) to include these requirements in all subcontracts issued pursuant to this Agreement when the subcontract may involve the transport of equipment, material, or commodities by ocean vessel.

XXI. RECYCLED PRODUCTS

The Contractor agrees to comply with all the requirements of Section 6002 of the Resource Conservation and Recovery Act (RCRA), as amended (42 U.S.C. 6962), including, but not limited to, the regulatory provisions of 40 CFR Part 247, and Executive Order 12873, as they apply to the procurement of the items designated in Subpart B of 40 CFR Part 247.

XXII. PRE-AWARD AND POST-DELIVERY AUDIT REQUIREMENTS *(applies to contracts for rolling stock*)

To the extent applicable, Contractor agrees to comply with the requirements of 49 U.S.C. § 5323(l) and FTA implementing regulations at 49 CFR Part 663, and to submit the following certifications:

A. Buy America Requirements: The Contractor shall complete and submit a declaration certifying either compliance or noncompliance with Buy America. If the Bidder/Offeror certifies compliance with Buy America, it shall submit documentation which lists (1) component and subcomponent parts of the rolling stock to be purchased identified by manufacturer of the parts, their country of origin and costs; and (2) the location of the final assembly point for the rolling stock, including a description of the activities that are planned to take place and actually took place at the final assembly point and the cost of final assembly.

B. Solicitation Specification Requirements: The Contractor shall submit evidence that it will be capable of meeting **the** bid specifications and provide information and

access to Recipient and its agents to enable them to conduct post-award and post-delivery audits.

C. Federal Motor Vehicle Safety Standards (FMVSS): The Contractor shall submit (1) manufacturer's FMVSS self-certification sticker **information** that the vehicle complies with relevant FMVSS or (2) manufacturer's certified statement that the contracted buses will not be subject to FMVSS regulations.

XXIII. FALSE OR FRAUDULENT STATEMENTS AND CLAIMS

A. The Contractor acknowledges that the provisions of the Program Fraud Civil Remedies Act of 1986, as amended, 31 U.S.C. §§ 3801 et seq. and U.S. DOT regulations, "Program Fraud Civil Remedies," 49 CFR Part 31, apply to its actions pertaining to this Project. Upon execution of the underlying Agreement, the Contractor certifies or affirms the truthfulness and accuracy of any statement it has made, it makes, it may make, or causes to be made, pertaining to the underlying contract or the FTA-assisted Project for which this contract work is being performed. In addition to other penalties that may be applicable, the Contractor further acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification, the Federal Government reserves the right to impose the penalties of the Program Fraud Civil Remedies Act of 1986 on the Contractor to the extent the Federal Government deems appropriate.

B. The Contractor also acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification to the Federal Government under a contract connected with a Project that is financed in whole or in part with Federal assistance originally awarded by FTA under the authority of 49 U.S.C. § 5307, the Government reserves the right to impose the penalties of 18 U.S.C. § 1001 and 49 U.S.C. § 5307(n)(1) on the Contractor, to the extent the Federal Government deems appropriate.

C. The Contractor agrees to include the above two clauses in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clauses shall not be modified, except to identify the subcontractor who will be subject to the provisions.

XXIV. FLY AMERICA

The Contractor agrees to comply with 49 U.S.C. 40118 (the "Fly America" Act) in accordance with the General Services Administration's regulations at 41 CFR Part 301-10, which provide that recipients and subrecipients of Federal funds and their contractors are required to use U.S. Flag air carriers for U.S. Government-financed international air travel and transportation of their personal effects or property, to the extent such service is

available, unless travel by foreign air carrier is a matter of necessity, as defined by the Fly America Act. The Contractor shall submit, if a foreign air carrier was used, an appropriate certification or memorandum adequately explaining why service by a U.S. flag air carrier was not available or why it was necessary to use a foreign air carrier and shall, in any event, provide a certificate of compliance with the Fly America requirements. The Contractor agrees to include the requirements of this section in all subcontracts that may involve international air transportation.

XXV. INCORPORATION OF FEDERAL TRANSIT ADMINISTRATION (FTA) TERMS

The preceding provisions include, in part, certain Standard Terms and Conditions required by DOT, whether or not expressly set forth in the preceding contract provisions. All contractual provisions required by DOT, as set forth in FTA Circular 4220.1F, are hereby incorporated by reference. Anything to the contrary herein notwithstanding, all FTA mandated terms shall be deemed to control in the event of a conflict with other provisions contained in this Agreement. The Contractor shall not perform any act, fail to perform any act, or refuse to comply with any (name of grantee) requests which would cause (name of grantee) to be in violation of the FTA terms and conditions.

XXVI. TRANSIT EMPLOYEE PROTECTIVE AGREEMENTS *(applicable to each contract for transit operations performed by employees of a Contractor recognized by FTA to be a transit operator)*

A. The Contractor agrees to the comply with applicable transit employee protective requirements as follows:

1. **General Transit Employee Protective Requirements** – To the extent that FTA determines that transit operations are involved, the Contractor agrees to carry out the transit operations work on the underlying contract in compliance with terms and conditions determined by the U.S. Secretary of Labor to be fair and equitable to protect the interests of employees employed under this contract and to meet the employee protective requirements of 49 U.S.C. A 5333(b), and U.S. DOL guidelines at 29 C.F.R. Part 215, and any amendments thereto. These terms and conditions are identified in the letter of certification from the U.S. DOL to FTA applicable to the FTA Recipient's Project from which Federal assistance is provided to support work on the underlying contract. The Contractor agrees to carry out that work in compliance with the conditions stated in that U.S. DOL letter. The requirements of this subsection A, however, do not apply to any contract financed with Federal assistance provided by FTA either for projects for elderly individuals and individuals with disabilities authorized by 49 U.S.C. § 5310(a)(2), or for projects for

nonurbanized areas authorized by 49 U.S.C. § 5311. Alternate provisions for those projects are set forth in subsections (2) and (3) of this clause.

2. **Transit Employee Protective Requirements for Projects Authorized by 49 U.S.C. § 5310(a)(2) for Elderly Individuals and Individuals with Disabilities** – If the contract involves transit operations financed in whole or in part with Federal assistance authorized by 49 U.S.C. § 5310(a)(2), and if the U.S. Secretary of Transportation has determined or determines in the future that the employee protective requirements of 49 U.S.C. § 5333(b) are necessary or appropriate for the state and the public body subrecipient for which work is performed on the underlying contract, the Contractor agrees to carry out the Project in compliance with the terms and conditions determined by the U.S. Secretary of Labor to meet the requirements of 49 U.S.C. § 5333(b), U.S. DOL guidelines at 29 C.F.R. Part 215, and any amendments thereto. These terms and conditions are identified in the U.S. DOL's letter of certification to FTA, the date of which is set forth Grant Agreement or Cooperative Agreement with the state. The Contractor agrees to perform transit operations in connection with the underlying contract in compliance with the conditions stated in that U.S. DOL letter.

3. **Transit Employee Protective Requirements for Projects Authorized by 49 U.S.C. § 5311 in Nonurbanized Areas** – If the contract involves transit operations financed in whole or in part with Federal assistance authorized by 49 U.S.C. § 5311, the Contractor agrees to comply with the terms and conditions of the Special Warranty for the Nonurbanized Area Program agreed to by the U.S. Secretaries of Transportation and Labor, dated May 31, 1979, and the procedures implemented by U.S. DOL or any revision thereto.

B. The Contractor also agrees to include the any applicable requirements in each subcontract involving transit operations financed in whole or in part with Federal assistance provided by FTA.

XXVII. NATIONAL ITS ARCHITECTURE POLICY *(Applicable to contracts for ITS projects)*

If providing Intelligent Transportation Systems (ITS) property or services, Contactor shall comply with the National ITS Architecture and standards to the extent required by 23 U.S.C. § 512, FTA Notice, "FTA National ITS Architecture Policy on Transit Projects," 66 FR 1455, et seq., January 8, 2001, and later published policies or implementing directives FTA may issue.

XXVIII. TEXTING WHILE DRIVING; DISTRACTED DRIVING

Consistent with Executive Order 13513 "Federal Leadership on Reducing Text Messaging While Driving", Oct. 1, 2009 (available at http://edocket.access.gpo.gov/2009/E9-24203.htm) and DOT Order 3902.10 "Text Messaging While Driving", Dec. 30, 2009, SFMTA encourages Contractor to promote policies and initiatives for employees and other personnel that adopt and promote safety policies to decrease crashes by distracted drivers, including policies to ban text messaging while driving, and to include this provision in each third party subcontract involving the Project.

XXIX. SEAT BELT USE

In compliance with Executive Order 13043 "Increasing Seat Belt Use in the United States," April 16, 1997, 23 U.S.C. Section 402 note, the SFMTA encourages Contractor to adopt and promote on-the-job seat belt use policies and programs for its employees and other personnel that operate company owned, rented, or personally operated vehicles, and to include this provision in each third party subcontract involving the Project.

XXX. LOBBYING *(To be submitted with each bid or offer exceeding $100,000)*

Certification Regarding Lobbying required (See Appendix E).

XXXI. PROMPT PAYMENT

A. In accordance with SFMTA's SBE/DBE Program, no later than three days from the date of Contractor's receipt of progress payments by SFMTA, the Contractor shall pay any subcontractors for work that has been satisfactorily performed by said subcontractors. Unless the prime Contractor notifies the CCO Director in writing within 10 working days prior to receiving payment from the City that there is a bona fide dispute between the prime Contractor and the subcontractor. Within five working days of such payment, Contractor shall provide City with a declaration under penalty of perjury that it has promptly paid such subcontractors for the work they have performed. Failure to provide such evidence shall be cause for City to suspend future progress payments to Contractors.

B. Contractor may withhold retention from subcontractors if City withholds retention from Contractor. Should retention be withheld from Contractor, within 30 days of City's payment of retention to Contractor for satisfactory completion of all work required of a subcontractor, Contractor shall release any retention withheld to the subcontractor. Satisfactory completion shall mean when all the tasks called for in the subcontract with subcontractor have been accomplished and documented as required by City. If the Contractor does not pay its subcontractor as required under

the above paragraph, it shall pay interest to the subcontractor at the legal rate set forth in subdivision (a) of Section 685.010 of the California Code of Civil Procedure.

XXXII. VETERANS EMPLOYMENT (*applicable to Capital Projects)*

As provided by 49 U.S.C. § 5325(k):

A. To the extent practicable, Contractor agrees that it:

1. Will give a hiring preference to veterans (as defined in 5 U.S.C. § 2108), who have the skills and abilities required to perform construction work required under a third party contract in connection with a capital Project supported with funds made available or appropriated for 49 U.S.C. chapter 53, and

2. Will not require an employer to give a preference to any veteran over any equally qualified applicant who is a member of any racial or ethnic minority, female, an individual with a disability, or a former employee, and

B. Contractor also assures that its subcontractor will:

1. Will give a hiring preference to veterans (as defined in 5 U.S.C. § 2108), who have the skills and abilities required to perform construction work required under a third party contract in connection with a capital Project supported with funds made available or appropriated for 49 U.S.C. chapter 53, to the extent practicable, and

Will not require an employer to give a preference to any veteran over any equally qualified applicant who is a member of any racial or ethnic minority, female, an individual with a disability, or a former employee.

.

Appendix H

SAN FRANCISCO MUNICIPAL TRANSPORTATION AGENCY
SMALL BUSINESS ENTERPRISE PROGRAM REQUIREMENTS

Architects, Engineers, Planners, and Environmental Scientists and Other Professional Services

I. POLICY

The San Francisco Municipal Transportation Agency (SFMTA), recipient of federal financial assistance from the Federal Transit Administration (FTA), is committed to and has adopted, a Small Business Enterprise (SBE) and Disadvantaged Business Enterprise (DBE) Program to implement the Disadvantaged Business Enterprise regulations in 49 C.F.R. Part 26 (the "Regulations"), issued by the Department of Transportation (DOT).

It is the policy of the SFMTA to ensure nondiscrimination in the award and administration of DOT-assisted contracts and to create a level playing field on which SBEs and DBEs can compete fairly for contracts and subcontracts relating to SFMTA's construction, procurement and professional services activities. To this end, SFMTA has developed procedures to remove barriers to SBE and DBE participation in the bidding and award process and to assist SBEs and DBEs to develop and compete successfully outside of the SBE/DBE program. In connection with the performance of this contract, the Contractor will cooperate with SFMTA in meeting these commitments and objectives.

Pursuant to 49 C.F.R. Section 26.13, the Contractor is required to make the following assurance in its agreement with SFMTA and to include this assurance in any agreements it makes with subcontractors in the performance of this contract:

The Contractor or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The Contractor shall carry out applicable requirements of 49 C.F.R. Part 26 in the award and administration of DOT-assisted contracts. Failure by the Contractor or subcontractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as SFMTA deems appropriate.

A. Applicability

Under 49 CFR Sections 26.3 and 26.51, and in response to the Federal Transit Administration's (FTA) March 23, 2006, publication of the Department of Transportation's

(DOT) guidance concerning the federal DBE program that applies to grant recipients within the Ninth Circuit, the SFMTA, a recipient of federal financial assistance from the FTA, is required to implement race-neutral means of facilitating DBE participation in instances where the SFMTA lacks evidence of discrimination or its effects on DBEs. Per DOT requirements, the SFMTA conducted a disparity study to determine if substantial disparities exist in the utilization of DBEs in the SFMTA's federally existed contracts. The results of the study concluded that for the SFMTA's professional services contracts, DBEs owned by women are underutilized, and DOT has authorized the SFMTA to establish contract goals for women-owned DBEs. The Regulations are incorporated into this Program as though fully set forth herein. This Program applies to all SFMTA contracts that are funded, in whole or in part, by DOT federal financial assistance.

B. Objectives

The objectives of this program are to:

1. Remove barriers to SBE and DBE participation in the bidding, award and administration of SFMTA contracts;
2. Assist SBEs and DBEs to develop and compete successfully outside of the Program;
3. Ensure that the Program is narrowly tailored in accordance with 49 C.F.R. Part 26;
4. Ensure that only SBEs and DBEs meeting the eligibility requirements are allowed to participate as SBEs and DBEs;
5. Identify business enterprises that are qualified as SBEs and DBEs and are qualified to provide SFMTA with required materials, equipment, supplies and services; and to develop a good rapport with the owners, managers and sales representatives of those enterprises;
6. Develop communications programs and procedures which will acquaint prospective SBEs and DBEs with SFMTA's contract procedures, activities and requirements and allow SBEs and DBEs to provide SFMTA with feedback on existing barriers to participation and effective procedures to eliminate those barriers; and
7. Administer the Program in close coordination with the various divisions within SFMTA so as to facilitate the successful implementation of this Program.

C. Administration of Program

The Director of Transportation is responsible for adherence to this policy. The DBE Liaison Officer (DBELO) shall be responsible for the development, implementation and monitoring of this program. It is the expectation of the Municipal Transportation Board of Directors and the Director of Transportation that all SFMTA personnel shall adhere to the provisions and the spirit of this program.

D. Prohibited Discrimination

SFMTA shall not exclude persons from participation in, deny benefits to, or otherwise discriminate against any persons in connection with the award and performance of any contract governed by the Regulations on the basis of race, color, sex or national origin. The City and County of San Francisco also prohibits discrimination on the basis of (the fact or perception of a person's) race, color, creed, religion, national origin, ancestry, age, sex, sexual orientation, gender identity, domestic partner status, marital status, disability or Acquired Immune Deficiency Syndrome or HIV status (AIDS/HIV status).

E. SFMTA shall not directly or through contractual or other arrangements, use criteria or methods of administration that have the effect of defeating or substantially impairing accomplishment of the objectives of this program with respect to individuals in the groups or categories or having the characteristics listed above.

F. SFMTA has signed the federal assurances regarding non-discrimination required under 49 C.F.R. Section 26.13. See III.D (Contract Assurances) for requirements of Contractor and Subconsultants.

II. DEFINITIONS

Any terms used in SFMTA's SBE/DBE Program that are defined in 49 C.F.R. Section 26.5 or elsewhere in the Regulations shall have the meaning set forth in the Regulations.

A. Disadvantaged Business Enterprise (DBE): A DBE is a for-profit, small business concern (1) that is at least 51% owned by one or more individuals who are both socially and economically disadvantaged, or, in the case of a corporation, in which 51% of the stock is owned by one or more socially and economically disadvantaged individuals; (2) whose management and daily business operations are controlled by one or more of the socially and economically disadvantaged individuals who own it; and (3) that is certified under the California Unified Certification Program.

B. Small Business Enterprise (SBE): An SBE is a for-profit, small business concern with a three-year average gross revenue not exceeding current SBA size standards

appropriate for its type of work and is either verified eligible by the SFMTA or the State of California's Small Business Program with the Department of General Services, the California Unified Certification Program with a U.S. Department of Transportation recipient, or the City and County of San Francisco's LBE program with the Contract Monitoring Division.

III. SBE/DBE PARTICIPATION AND SUBCONTRACTING REQUIREMENTS

A. SBE and DBE Participation Goals

The following participation goals have been established for this Contract:

SBE 5%

This goal will apply to the following types of contracts or scope of work in the contract: Construction – Building, Heavy; Construction-Dredging and Surface Cleanup; Construction (specialty trades); General Freight Trucking; Hazardous Waste Collection, Trucking; Remediation; Testing Labs; Computer Programming and Design; Architecture & Engineering services (to include professional and technical services); Surveying and Mapping; Drafting (Design Services); Landscape Architecture; Building Inspection; Machinery and Equipment Rental (Construction); Merchant Wholesalers, Durable Goods; Public Relations; and Telecommunications.

B. Determining the Amount of SBE and DBE Participation

The SFMTA strongly encourages the prime contractor to make every good faith effort to include SBEs and DBEs to perform meaningful work in all aspects of the projects. To accomplish this goal, the following guidance is provided:

1. SBE and DBE Participation

SBE and DBE participation includes contracts (other than employee contracts) with SBEs and DBEs for any goods or services specifically required for the completion of the work under the Agreement. An SBE or DBE may participate as a prime contractor/consultant, subcontractor/consultant, joint venture partner with a prime or consultant, vendor of material or supplies incorporated or expended in the work, or a supplier of other services such as shipping, transportation, testing, equipment rental, insurance services and other support services necessary to fulfill the requirements of the Agreement.

2. Function

SBEs and DBEs must perform a commercially useful function, i.e., must be responsible for the execution of a distinct element of work and must carry out its responsibility by actually performing, managing and supervising the work. However, an SBE or DBE may contract out a portion of the work if it is considered to be a normal industry practice. If an SBE or DBE contractor subcontracts a significantly greater portion of the work of the contract than

would be expected on the basis of normal industry practices, the SBE or DBE shall be presumed not to be performing a commercially useful function.

3. Determining the amount of SBE and DBE Participation

SBE and DBE participation includes that portion of the contract work actually performed by a certified SBE or DBE with its own forces. An SBE or DBE may participate as a prime contractor, subcontractor, joint venture partner, or vendor or supplier of materials or services required by the contract.

An SBE's or DBE's participation can only be counted if it is performing a commercially useful function. An SBE or DBE is performing a commercially useful function when it actually performs, manages and supervises a portion of the work involved. There is a rebuttable presumption that if the SBE or DBE is not responsible for at least 30 percent of the work with its own forces, or subcontracts a greater portion of the work than the normal industry standard, it is not performing a commercially useful function.

The Contractor shall determine the amount of SBE and DBE participation for each SBE and DBE performing work on the contract in terms of both the total value of the work in dollars and the percentage of the total contract bid price. The Contractor shall also determine the total amount of SBE and DBE participation for the entire contract. The Contractor shall count SBE and DBE participation according to the following guidelines:

a. SBE or DBE Prime Contractor

Count the entire dollar amount of the work performed or services provided by the SBE's or DBE's own forces, including the cost of materials and supplies obtained for the work and the reasonable fees and commissions charged for the services. Do not count any work subcontracted to another firm as SBE or DBE participation by the SBE or DBE Prime Contractor.

b. SBE or DBE Subcontractor

Count the entire amount of the work performed or services provided by the SBE's or DBE's own forces, including the cost of materials and supplies obtained for the work (except for materials and supplies purchased or leased from the Prime Contractor) and reasonable fees and commissions charged for the services. Do not count any work subcontracted by an SBE or DBE subcontractor to another firm as SBE or DBE participation by said SBE or DBE subcontractor. If the work has been subcontracted to another SBE or DBE, it will be counted as SBE or DBE participation by that other SBE or DBE.

c. SBE or DBE Joint Venture Partner

Count the portion of the work that is performed solely by the SBE's or DBE's forces or if the work is not clearly delineated between the SBE or DBE and the joint venture

partner, count the portion of the work equal to the SBE's or DBE's percentage of ownership interest in the joint venture.

d. SBE or DBE Regular Dealer

Count 60 percent of the costs of materials and supplies obtained from an SBE or DBE regular dealer that owns, operates or maintains a store or warehouse in which the materials and supplies are regularly bought, kept in stock and sold or leased to the public in the usual course of business (except regular dealers of bulk items such as petroleum, cement and gravel who own and operate distribution equipment in lieu of maintaining a place of business). This applies whether an SBE or DBE is a prime contractor or subcontractor.

e. Other SBEs or DBEs

Count the entire amount of fees or commissions charged for assistance in procuring or delivering materials and supplies when purchased from an SBE or DBE that is not a manufacturer or regular dealer. Do not count the cost of the materials and supplies.

C. Submission of Certification for SBEs and DBEs

All firms wishing to receive credit for participation under the SFMTA's SBE/DBE Program must be certified as bona fide SBEs or DBEs with the SFMTA. This requires either submission of: (1) the completed certification applications for either SBEs, DBEs, or LBEs, or (2) submission of the SFMTA's small business verification application. For information regarding where to obtain applications for these certifications, please contact the SFMTA Contract Compliance Office at:

San Francisco Municipal Transportation Agency
Contract Compliance Office
One South Van Ness Avenue, 6th floor
San Francisco, California 94103
(415) 646-2366
Attn: Regina Chan
regina.chan@sfmta.com

D. Contract Assurances

The Contractor and its subcontractors shall not discriminate on the basis of race, color, national origin, or sex in the performance of the contract. The Contractor and its subcontractors shall carry out applicable requirements of 49 C.F.R. Part 26 in the award and administration of DOT-assisted contracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as the recipient deems appropriate, which may include, but is not limited to: (1) withholding monthly progress payments; (2) assessing sanctions; (3) liquidated damages; and/or (4) disqualifying the contractor from future bidding as non-responsible.

E. Use of SBE and DBE Firms

The Consultant shall use the specific SBEs and DBEs listed to perform the work and supply the materials for which each is listed unless the Consultant obtains CCO's prior written consent. Unless prior written consent by CCO is provided, the Consultant shall not be entitled to any payment for work or material unless it is performed or supplied by the listed SBE or DBE.

F. Substitution of Subconsultants and Suppliers

The Consultant shall not terminate an SBE or DBE subconsultant or supplier for convenience and then perform the work with its own forces. Before requesting the termination and/or substitution of an SBE or DBE subconsultant, the Consultant must give notice in writing to the SBE or DBE subconsultant, with a copy to CCO, of its intent to request to terminate and/or substitute, and the reason for the request. The Consultant must give the SBE or DBE five days to respond to the notice and advise CCO and the Consultant of the reasons, if any, why it objects to the proposed termination of its subcontract and why the Consultant's request should not be approved. CCO must approve the request in writing in order for the substitution to be valid. The substitution may also have to be approved by the SFMTA Board of Directors.

When an SBE or DBE subconsultant is terminated as provided in this section, or fails to complete its work on the contract for any reason, the Consultant shall make good faith efforts to find another SBE or DBE subconsultant to substitute for the original SBE or DBE. These good faith efforts shall be directed at finding another SBE or DBE to perform at least the same amount of work under the contract as the SBE or DBE that was terminated, to the extent needed to meet the established SBE or DBE contract goal.

G. Addition of Subconsultants and Suppliers

The Consultant shall notify CCO prior to any addition of an SBE/DBE or non-SBE/non-DBE subconsultant or supplier to the project. Submit SBE/DBE SFMTA Form No. 4 for each new SBE or DBE subconsultant or supplier. Any new SBE or DBE subconsultant or supplier approved by CCO also must submit SFMTA SBE/DBE Form No. 5.

H. Prompt Payment to Subcontractors

In accordance with SFMTA's SBE/DBE Program, no later than three days from the date of Contractor's receipt of progress payments by SFMTA, the Contractor shall pay any subcontractors for work that has been satisfactorily performed by said subconsultants. Unless the prime consultant notifies the CCO Director in writing within 10 working days prior to receiving payment from the City that there is a bona fide dispute between the prime consultant and the subconsultant. Within five working days of such payment, Consultant shall provide City with a declaration under penalty of perjury that it has promptly paid such subconsultants for the work they have performed. Failure to provide such evidence shall be cause for City to suspend

future progress payments to Consultants. Effective January 1, 2019, the CCO will implement an online contract compliance monitoring system, B2GNow. If this contract is awarded after implementation of B2GNow, rather than completing and submitting SBE/DBE Form No. 7, the Consultant shall enter its subconsultant payment information into the B2GNow system. Subconsultants are then required to acknowledge payment from the Consultant online using the B2GNow system. B2GNow system training will be made available to the Consultant and its subconsultants.

Consultant may withhold retention from subconsultants if City withholds retention from Consultant. Should retention be withheld from Consultant, within 30 days of City's payment of retention to Consultant for satisfactory completion of all work required of a subconsultant, Contractor shall release any retention withheld to the subconsultant. Satisfactory completion shall mean when all the tasks called for in the subcontract with subconsultant have been accomplished and documented as required by City.

If the Consultant does not pay its subconsultant as required under the above paragraph, it shall pay interest to the subconsultant at the legal rate set forth in subdivision (a) of Section 685.010 of the California Code of Civil Procedure.

IV. MONITORING AND COMPLIANCE

A. SBE and DBE Records; Reporting Requirements

The Contractor shall maintain records of all SBE and DBE participation in the performance of the contract including subcontracts entered into with certified SBEs and DBEs and all materials purchased from certified SBEs and DBEs.

The Contractor shall submit SBE and DBE participation reports to SFMTA on a monthly basis, or as otherwise directed by the CCO. The reports shall identify the name and address of each SBE and DBE performing work on the project, and show the total dollar amount requested for payment and the total dollar amount actually paid to each SBE and DBE. Within thirty (30) days of completion of the contract, or as otherwise directed by the CCO, the Contractor shall submit a final summary SBE/DBE report to the CCO.

B. Noncompliance; Administrative Remedies

SFMTA will implement appropriate mechanisms to ensure that its prime contractors and subcontractors comply with SBE/DBE Program regulatory requirements. SFMTA will apply legal and contractual remedies available under federal, state and local law.

SFMTA will also include a monitoring and enforcement mechanism to verify that the work committed to SBEs and DBEs at contract award is actually performed by the SBEs and

DBEs. This mechanism will provide for a running tally of actual SBE and DBE attainments and include a provision ensuring that SBE and DBE participation is credited toward overall or contract goals only when payments are actually made to SBE and DBE firms.

Appendix I

Performance and Service Level Requirements

I1 Performance Requirements. The Contractor shall design and implement the CBTC System and provide Services to support the CBTC System so that it meets the Performance Requirements listed in this Appendix I, Table 1.

I1.1 Use of Performance Requirements. The Performance Targets marked with an asterisk (*) in this Appendix I, Table 1 shall be used to calculate the Performance-Based Monthly Support Fee as described in Appendix B Section B2.2.4 (Calculation of Performance-Based Monthly Support Fee Adjustments).

Table 1: Performance Requirements

Row	Performance Metric	Calculation	Target
1	Lost Minutes per Year (minutes)	Calculated as specified in the Contract Specifications (Appendix A), Section 30 (Reliability, Availability, Maintainability (RAM))	1248
2	System Availability (X)*		99.96%
3	Minimum System Mean Time Between Failures (hours)		12,430
4	Mean Uptime (hours)		6,932
5	Mean Corrective Maintenance Time (MCMT) (hours)		0.45
6	Maximum Mean Corrective Maintenance Time ($MCMT_{MAX95}$) (hours)		1
7	Mean Time to Restore (minutes)		2
8	Maximum Preventative Maintenance Person-hours (per year)		2,970
9	Maximum Corrective Maintenance Person-hours (per year)		800
10	Confidence Limit		95%
11	Service Affecting Failures (per year)		15
12	Loss of Critical Function (Z)* (LCF) (per year)		1

13	Reduction in Operating Margin (Y)* (hours), per year		88

* Indicates that this value is used in the Performance-Based Monthly Support Fee calculation as provided for in Appendix B2.2.4 (Calculation of Performance-Based Monthly Support Fee Adjustments).

I2 Service Levels for Technical Support Services. As part of the Warranty Services described in Contract Specifications, Section 13 (Warranty and Spare Parts) and the Support Services described in Contract Specifications, Section 32 (Support Services), Contractor shall provide technical support for Issues with the CBTC System as reported by the SFMTA using the following procedures.

I2.1 Severity Levels. There are three possible Severity Levels for Issues. SFMTA will assign one of the following Severity Levels to each Issue when it reports the Issue to Contractor. If Contractor does not receive a Severity Level from SFMTA in the initial report, Contractor shall ask the Owner's Representative to assign a Severity Level at the next available opportunity.

I2.1.1 Urgent. The Issue is causing a Service Delay greater than 2 minutes. A Service Delay is the interruption in transit service in which a one or more vehicles are stopped for two or more minutes due to a CBTC System Issue, or there is degradation or loss of functionality to the System such that one or more trains proceed slowly and fall more than two minutes behind schedule.

I2.1.2 Priority. The Issue is affecting rail operations but is not causing a Service Delay. Important functionality described in the Contract Specifications or the Contractor's manuals is not available, or SFMTA staff cannot perform routine operations, or the System is operating in a degraded mode. The Issue is causing a significant business impact, which is increasing the workload of SFMTA operations or maintenance staff to continue transit operations.

I2.1.3 Routine. All other Issues reported by the SFMTA.

I2.2 Incident Reporting and Handling Process

I2.2.1 Reporting. SFMTA staff may report Issues to Contractor by telephone call, text or email to Contractor, or electronically using a Contractor-provided system.

I2.2.1.1 When reporting Issues by telephone or text, SFMTA staff will describe the Issue in detail and will provide the name and phone number of the SFMTA contact person responsible for addressing the Issue with Contractor.

I2.2.1.2 When reporting Issues by email, SFMTA staff will use Contractor's CBTC Issue Report Form.

I2.2.1.3 Contractor's electronic reporting system shall mirror the same fields and format as the Issue Report Form.

I2.2.2 Contractor Handling. Contractor shall use the information in the Issue Report Form to log the Issue and assign a Severity Level based on the information provided in SFMTA's report. If the SFMTA staff submitting the report indicates the Severity Level, Contractor must assign that Severity Level.

I2.2.2.1 When it has received an Issue report by telephone call or text, Contractor shall immediately fill in the CBTC Issue Report Form and email the completed form to the SFMTA's Owner's Representative as acknowledgment of receipt within 10 minutes of the receipt of the text or the end of the telephone call.

I2.2.2.2 Contractor shall acknowledge receipt of Issue reports made by email by a reply to the email made within one hour of receipt.

I2.2.2.3 Issue reports made using Contractor's electronic reporting system shall be acknowledged immediately upon the SFMTA submitting the report. Contractor's electronic reporting system shall automatically issue an email receipt to SFMTA's Owner's Representative as acknowledgment.

I2.2.3 Disputes Involving Severity Level. If Contractor disagrees with the SFMTA's Severity Level assessment, Contractor may request a reevaluation of the Severity Level. Requests for reevaluation shall be directed to the Owner's Representative. After Contractor resolves the Issue, the SFMTA will make a final evaluation as to the Issue's severity. So long as Contractor meets the response and Resolution Time requirements in Table 2 within the time limit associated with the final assessment, the Issue will not count towards the Unsatisfactory Issue Tally.

I2.2.4 Issue Report Form. Contractor's Issue Report Form shall, at a minimum, collect the following information:

a. A unique identifier for referencing the Issue
b. A description of the Issue
c. The time and date the Issue was observed
d. The name and contact information of the person reporting the Issue
e. The subsystem(s) and/or Equipment affected by the Issue
f. The Severity Level
g. A narrative justification of the Severity Level, to include a description of the impacts to service and operations.

h. Steps taken by SFMTA to troubleshoot, mitigate or address the Issue.

I2.3 Issue Response and Resolution

I2.3.1 Calculation of Response and Resolution Times. All times in this section are calculated from the time Contractor acknowledges receipt of the Issue report, as marked on the Issue Report Form according to the handling instructions in Section I2.2.2 (Contractor Handling). If Contractor does not acknowledge receipt, the times will start using the maximum times described in Section I2.2.2.

I2.3.2 Response. Contractor shall respond to Issue reports within the Target Response Time established in this Appendix I, Table 2, based on the Severity Level. A response will have occurred at the time of the commencement of work (inclusive of analysis, root cause determination, and development of a fix) coupled with a communication from the Contractor to SFMTA that work has begun.

I2.3.3 Root Cause Disposition. Contractor shall transmit a report meeting the requirements in Contract Specifications Section 30.2.3 (Root Cause Analysis) that describes the root cause of an Issue to the SFMTA within the Target Root Cause Disposition time established in this Appendix I, Table 2, based on the Severity Level.

I2.3.4 Resolution. Contractor shall resolve the issue within the Target Resolution Time established in Appendix I (Performance and Service Level Requirements), Table 2, based on the Severity Level. An Issue is resolved either when Contractor performs an action, such as a design modification, Software release, or recall of Equipment, that Contractor and SFMTA agree will address the Issue such that the Issue no longer will occur. Issues may also be resolved using a workaround or if they cannot be duplicated, as described in this Section. These actions only establish the end of the Resolution Time if SFMTA acknowledges the Issue has been resolved satisfactorily as described in I2.3.4.3 (Closure).

I2.3.4.1 Workarounds. An Urgent Issue where the Contractor has applied a workaround or stopgap solution which reduces its Severity Level may be resolved. A workaround is a procedure designed to avoid the conditions which cause the Issue, such that if the workaround procedure is followed, the Issue will not occur. To resolve the Urgent Issue, Contractor shall develop a written workaround procedure or operating restriction to SFMTA, fill out a new Issue Report Form logged at the new Severity Level and transmit the workaround procedure or operating restriction and the new Issue Report Form to the

Owner's Representative. Issues with a Severity Level of "Priority" or "Routine" may not be resolved using a workaround.

I2.3.4.1.1 Failure to Follow Workaround. If the Contractor has resolved an Urgent Issue using a workaround or operating restriction, and the Urgent Issue reoccurs because SFMTA did not follow the workaround procedure or operating restriction, the resulting Malfunction or failure shall not be considered a new Issue and shall not be chargeable under the FRACAS process described in Contract Specifications Section 30 (RAM).

I2.3.4.2 No Fault Found. Issues which cannot be duplicated, or for which Contractor cannot find determine a cause may be deemed resolved, unless SFMTA can show Contractor that the Issue still exists. Issues resolved in this way shall be distinguished from other resolved Issues so that they may be reopened if the Issue recurs.

I2.3.4.3 Closure. Upon SFMTA's acknowledgment that the Issue has been resolved satisfactorily, the issue may be closed, which removes it from the Unsatisfactory Issues Tally, if applicable.

Table 2: Response and Resolution Times

Performance Metric	Calculation	Target
Response Time	Maximum number of minutes between a trouble call and the initiation of troubleshooting or repair work *per incident* before affecting Monthly Support Fee	Example: 5 min
Urgent: An Issue with the train control System is causing a Service Delay.		15 mins
Priority: An Issue with the train control System is affecting rail operations.		15 mins
Routine: Any other Issue		60 mins via helpdesk, 1 business day via email.
Root Cause Disposition Time	Maximum number of hours *per incident* between the initiation of troubleshooting and a report sent to the SFMTA detailing a root cause, before affecting Monthly Support Fee	Example: 1 hour
Urgent: An Issue with the train control System is causing a Service Delay.		1 hour* (see note in Assumptions)
Priority: An Issue with the train control System is affecting rail operations.		7 days
Routine: Any other Issue		60 days
Resolution Time	Maximum number of hours *per incident* that tickets are open before affecting Monthly Support Fee	Example: 1 hour
Urgent: An Issue with the train control System is causing a Service Delay.		2 hours* (see note in Assumptions)
Priority: An Issue with the train control System is affecting rail operations.		90 days
Routine: Any other Issue		180 days

I2.4 Calculation of Unsatisfactory Issues Tally. The number of issues which are not resolved satisfactorily ("Unsatisfactory Issues") each month affects the Performance-Based Monthly Support Fee calculation, as provided for in Appendix B2.2.4

(Calculation of Performance-Based Monthly Support Fee Adjustments). This section provides the procedures for calculating this tally.

I2.4.1 Unsatisfactory Issue Designation and Scoring. An Issue is designated as an Unsatisfactory Issue if the Response Time, Root Cause Disposition time, or Resolution Time exceeded the Targets established in Appendix I, Table 2. An Unsatisfactory Issue can have a score of 1, 2, or 3 depending on whether one, two or all three of these targets have been exceeded.

I2.4.2 Monthly Tally. Each month, the Unsatisfactory Issues are tallied by summing the score for each Unsatisfactory Issue as provided for in I2.4.1 (Unsatisfactory Issue Designation and Scoring) above. Each Unsatisfactory Issue can add 1, 2, or 3 to the tally. All Unsatisfactory Issues are tallied each month, starting with the month they are first designated Unsatisfactory, until they are closed. Each month, SFMTA will compare this Unsatisfactory Issues Tally to the values in Appendix B2 (Calculation of Charges), Table 6 when calculating the Contractor's Monthly Support Fee.

I3 Software Release Schedule. During the Support Term of this Agreement and as part of the included Support Services, the Contractor shall provide Software Releases meeting the requirements in Contract Specifications, Section 32.4.9 (Regular Software Releases) at the regular frequency specified in this Appendix I. Table 3.

Table 3: Software Release Schedule (Descriptions of the subsystem are specified in these sections of the Contract Specifications)

Proposer may add additional lines to this Table e if necessary to describe its intended software update schedule.

Frequency (e.g., every 5 years, annually, quarterly, semi-annually)	ATS (Section 17)	Every 3-5 years
	ATO/ATP (Sections 18 and 19) Central Equipment	Every 3-5 years
	Wireless Network (Section 26.4)	1-2 years
	NMS (Section 20.3)	1-2 years
	NSS (Section 6.5)	Every 3-5 years
	Zone/Object Controllers (Section 27.8.1)	5 years
	Interlockings (Section 27.8.2)	5 years
	Onboard Equipment (Section 24)	5 years
	Workstations (Section 27.7.3)	Annually

	CMMS (Section 20.2)	5 years

Appendix J

SFMTA Policies and Procedures

The attached documents in this Appendix J are the current versions (at time this Agreement was signed) of SFMTA Policies and Procedures applicable to the Work. From time to time the SFMTA my update these Policies and Procedures. The SFMTA Project Manager will communicate changes to these attached Policies and Procedures in writing, and in that communication provide replacement policy and procedure documents. When provided, those replacement documents will supersede the original documents in this Appendix J.

Appendix J includes the following documents:

(1) SFMTA Track and Tunnel Access Procedures
(2) Barcoding Procedures
(3) Technology Change Control Policy and Procedures
(4) System Safety Rail Change Control Board Policy
(5) SFMTA Rail Rule Book
(6) Train Control System Upload Template
(7) SFMTA Technology Project Requirements
(8) Construction Regulations Blue Book

These Policies and Procedures are voluminous and will be separately provided to the Contractor.

Appendix K

CBTC Software License Agreement

Hitachi Rail GTS USA Inc.
SFMTA CONTRACT SFMTA-2022-40 FTA

ARTICLE 1 Purpose of Software License Agreement

This Software License Agreement (Software License) is subordinate to and is incorporated into SFMTA Contract SFMTA-2022-40 FTA ("Agreement). The terms and conditions of the Agreement apply to the Contractor's provision and management of all software components of the CBTC System, regardless of the physical location of the software product. This Software License sets out additional terms and conditions applicable to the Software that Contractor will provide to the SFMTA under the Agreement.

ARTICLE 2 Definitions

The following definitions and the definitions of terms provided in the General Provisions and the terms defined in the Contract Specifications apply to this Software License.

2.1. "Authorized Users" means a person authorized by City to access the City's Application, including any City employee, contractor, or agent, or any other individual or entity authorized by City.

2.2. "Disabling Code" means computer instructions or programs, subroutines, code, instructions, data or functions (including but not limited to viruses, worms, date bombs or time bombs), including but not limited to other programs, data storage, computer libraries and programs that self-replicate without manual intervention, instructions programmed to activate at a predetermined time or upon a specified event, and/or programs purporting to do a meaningful function but designed for a different function, that alter, destroy, inhibit, damage, interrupt, interfere with or hinder the operation of the City's access to the Application System Services through Contractor's Website and/or Authorized User's processing environment, the system in which it resides, or any other software or data on such system or any other system with which it is capable of communicating.

2.3. "Software" means all or one or more of the proprietary computer software programs necessary to operate, manage, test, train, analyze, report, or perform any other function of the CBTC System described in the Agreement. The Software comprises Contractor software

programs and third-party software programs and subprograms identified in Appendix A, all related materials, Documentation, all corrections, patches or updates thereto, and other written information received by City from Contractor under the Agreement, whether in machine-readable, embedded in Equipment, Server-Based, Hosted, or printed form.

2.4. "Software Acceptance" means notice from the City to Contractor that the Software meets the specifications and requirements of the Agreement.

2.5. "Software Acceptance Period" means the period allocated by City to test the Application to determine whether it conforms to the applicable Contract requirements and, if appropriate, properly operates in the defined operating environment, is capable of running on a repetitive basis, and is otherwise in compliance with the service level obligations without failure, which shall occur as part of the System Reliability, Availability, and Maintenance (RAM) performance testing. See Contract Specifications Sections 31, 30, and 13 for requirements concerning Software Acceptance testing, RAM, and Warranty Periods.

2.6. "Software Documentation" means technical publications provided by Contractor to City relating to use of the Software, including but not limited to reference, administrative, maintenance, and programmer manuals.

2.7. "Software License" means this contract document and any attached appendices, and all applicable City Ordinances and Mandatory City Requirements which are specifically incorporated into this Software License by reference as provided herein.

2.8. "Software Support Services" means the Services Contractor shall provide the SFMTA as Support Services, as described in Section 32 of the Contract Specifications.

2.9. "Source Code" means the human readable compliable form of the Software.

2.10. "Subsequent Release" means a release of the Software for use in a particular operating environment which supersedes, replaces, and/or improves the Software installed in that environment. A Subsequent Release is offered and expressly designated by Contractor as a replacement to a specified Software product. A Subsequent Release will be supported by Contractor in accordance with the terms of the Agreement.

ARTICLE 3 Software License

3.1. Grant of License. Subject to the terms and conditions of this Agreement, Contractor grants to City a non-exclusive and non-transferable, perpetual, unlimited enterprise license to use the Software. City acknowledges and agrees that the Software is the proprietary information of Contractor and that this Agreement grants City no title or right of ownership in the Software.

3.1.1. Restrictions on Use. City is authorized to use the Software only for City's municipal purposes. City agrees that it will, through its best efforts, not use or permit the Software to be used in any manner, whether directly or indirectly, that would enable any other person or entity not authorized by this Agreement, to use the Software.

3.1.2. Disaster Recovery Copy. For the purpose of any bona fide City disaster recovery plan or with respect to the use of computer software in its municipal operations, City may make one copy of the Software for archival purposes and use such archival copy to restore use of the Software on a site owned or controlled by City. The use of such archival copy shall be limited to (1) the purpose of conducting limited testing of the disaster recovery plan's procedures and effectiveness and (2) during any period subsequent to the occurrence of an actual disaster during which the City cannot operate the Software on the existing site.

3.1.3. Transfer of Products. City may move the Software and supporting materials to another City site.

3.1.4. Documentation. Contractor shall provide City with the Software specified in this Agreement, and an electronic copy of the Software Documentation per installation. Contractor grants to City permission to duplicate all printed Software Documentation for City's municipal use.

3.2. Authorized Modification. Contractor shall cooperate with City to develop, use and modify Application Program Interfaces (APIs), macros and user interfaces. For purposes of this Agreement, such development shall be deemed an authorized modification. Contractor shall make no claim under this Agreement to ownership of any APIs, macros or other interfaces developed by or at the direction of the City. Contractor has no general objection to the City's use of third-party programs in conjunction with the Software licensed under this Agreement. Contractor recognizes that City has and will license third party programs that City will use with Contractor's products. Based on information provided to Contractor as to the Effective Date, Contractor agrees that such use does not constitute an unauthorized modification or violate the licenses granted under this Agreement.

3.3. Delivery and Installation of Software. Contractor shall deliver and install the Software as specified in the Contract Specifications.

3.4. Acceptance Testing. See Contract Specifications.

3.5. Nondisclosure. City agrees that it shall treat the Software as Contractor's Confidential Information and proprietary information in accordance with Section 13.1 of the General Provisions.

3.6. Discontinuance of Support. In addition to other Contractor obligations and City remedies provided in the Agreement or under law, Contractor agrees that in the event it discontinues its obligations under the terms of this Agreement, except as expressly provided for in Article 10 ("Termination and Default"), or ceases to market and/or provide maintenance and Support Services for the Software, and there is no successor in interest by merger, operation of law, assignment, purchase, or otherwise, it will provide City, without charge, one (1) copy of the then-current Source Code for all of the programs and all supporting Software Documentation for the Software then operating and installed at City's locations. If City should obtain the Source Code and the Software Documentation pursuant to this section, the only use made of the Source Code and the Software Documentation will be for the proper maintenance of the Software in connection with City's use of the Software as provided for, and limited by, the provisions of this Agreement.

ARTICLE 4 Term of the Software License

4.1. Term. The term of this Software License will commence on the Effective Date of the Agreement. The term of the Software License is perpetual and shall survive the termination or expiration of the CBTC Agreement.

ARTICLE 5 Terms and Conditions

5.1. Terms and Conditions of the Agreement Incorporated by Reference. This Software License is appended to the Agreement and is incorporated by reference into the Agreement. The terms and conditions stated in the Agreement apply to this Software License.

5.2. Software License and Services Fees. Contractor's Software License and Services Fees are incorporated into the progressive compensation provided for Milestones completion, work progression payments, and Support Fees set out in Appendix B to the Agreement. The SFMTA will not compensate Contractor separately for the Software License or Software Services.

5.3. Control of Data and System. The SFMTA shall at all times have full control of the CBTC System's operations and data. The SFMTA shall at all times have full control over access to the System and System Data. SFMTA shall determine who are Authorized Users and their respective levels of access. Contractor shall not utilize any Disabling Code or other System features that would allow Contractor to disable or in any way interfere with the SFMTA's operation of the System, access to the System of any part of the System, or access to System Data. All Software and Applications used in the System or to support the System or in any part

of the Services shall at all times be under SFMTA control, irrespective of whether the Software or Applications are installed on servers on SFMTA property, remote servers, or servers that operate over the internet (i.e., Cloud-based applications).

5.4. Copyright and Patent Infringement. Contractor shall fully indemnify and defend any claim or legal action alleging that the System or any part of the System or the SFMTA's use of the System is unlawful, unauthorized, unlicensed, or infringes on any copyright or patent, without restriction or limitation of any kind. See General Provisions, Article 6.

5.5. Proprietary Markings. City agrees not to remove or destroy any proprietary markings or proprietary legends placed upon or contained within the Software or any related materials or Documentation.

5.6. Services Contractor Agrees to Perform. Contractor's Services, including Support Services, are described in the General Provisions, and Appendix A to the Agreement ("Contract Specifications").

5.7. Security. Contractor shall ensure that all electronic transmission or exchange of City Data will be encrypted using current industry standards. Contractor shall also ensure that all data exchanged shall be used expressly and solely for the purposes stated in the Agreement. City Data shall not be distributed, repurposed, or shared across other applications, environments, or business units of Contractor not involved in administration of this Agreement, unless otherwise permitted in this Agreement. Remote access to view City data by Contractor for development and technical support purposes from outside the United States is allowed as long as City Data remains hosted solely on systems residing in the continental United States.

5.7.1. Document Delivery. Contractor will deliver completed Software Documentation in electronic format for the Software as part of the System Final Design Review package as described in Section 4.2.3. The Software Documentation will describe the functions and features of the Software, including all subsequent revisions thereto. The Software Documentation shall be understandable by a typical end user and shall provide Authorized Users with sufficient instruction such that an Authorized User can become self-reliant with respect to access and use of the Software. City shall have the right to make any number of additional copies of the Software Documentation at no additional charge.

5.8. Contractor Warranties.

5.8.1. Warranty of Performance. Contractor warrants that when the Software specified in the Agreement and all updates and improvements to the Software are delivered to City, they will be free from defects as to design, material, and workmanship and will perform in accordance with the Contract Specifications.

5.8.2. Compliance with Description of Services. Contractor represents and warrants that the Software all Updates and Upgrades will comply in all material respects with the Contract Specifications.

5.8.3. Title. Contractor represents and warrants to City that it is the lawful owner or license holder of all Software, materials and property identified by Contractor as Contractor-owned and used by it in the performance of the Services contemplated hereunder and the Contractor has the right to issue this Software License to permit City to use Software, the System, and each component thereof. To the extent that Contractor has used Open Source Software ("OSS") in the development of the Software, the CBTC System, and the Services, Contractor represents and warrants that it complies with any applicable OSS license(s), it has sufficient licensed rights to use and relicense to the City any included code in the Software, and Contractor is not infringing on any third party's patent or copyright in its use and licensing the Software to the City.

5.8.4. Disabling Code. Contractor represents and warrants that the Software on and Services, and any information, reports or other materials provided to City as a result of the operation of the System, including future Upgrades, Updates and other enhancements and modifications of the Software and the System shall be free of any Disabling Code.

5.8.5. Warranty of Suitability for Intended Purpose. Contractor warrants that the Software and Services will be suitable for the intended purpose of the Agreement.

5.9. Accessibility Requirements - Compliance with Americans with Disabilities Act.

5.9.1. Contractor shall ensure and warrants that all products and services consisting of or utilizing electronic, information or communication technology (EICT), including but not limited to software and web-based applications, meet the applicable requirements of each of the following statutes, regulations, standards, guidelines and policies ("Requirements"):

(a) California Government Code (Cal. Gov. Code) Section 11135, which prohibits discrimination on the basis of physical or mental disability and other grounds;

(b) Section 202 of the Americans with Disabilities Act of 1990, as amended (42 U.S.C. 12132, et seq.), and the federal rules and regulations adopted in implementation thereof, which are incorporated in California law by Cal. Gov. Code Section 11135;

(c) Cal. Gov. Code Section 7405, which:

(i) Incorporates in California law Section 508 of the Rehabilitation Act of 1973, as amended [29 United States Code (USC) Sec. 794d], and implementing regulations, as set forth in 36 Code of Federal Regulations (CFR) Part 1194, as in effect on March 19, 2017; and

(ii) Requires Contractors with state governmental entities subject to Cal. Gov. Code Section 11135 to respond to and resolve complaints regarding accessibility of its EICT products and related services;

(d) To the extent any telecommunications products or services are provided under the contract, 47 USC Section 255 and related regulations, including:

(i) 47 CFR Parts 6, 7, 14 and (if real-time text functionality is provided) 67, and

(ii) 36 CFR Part 1193, to the extent it remains in effect;

5.9.1.2 California Fair Employment and Housing Act (Cal. Gov. Code sections 12900-12951 & 12960-12976);

(e) Unruh Civil Rights Act (California Civil Code section 51);

(f) Disabled Persons Act (California Civil Code sections 54-54.1);

(g) Cal. Gov. Code sections 19230-19237;

(h) Web Content Accessibility Guidelines (WCAG) 2.0 Levels A and AA; and

(i) WCAG 1.0 Level AA, to the extent these guidelines include additional requirements that are not included in and are not inconsistent with WCAG 2.0 Levels A and AA and WCAG 2.1, as updated from time to time.

5.9.2. Contractor shall ensure that its products and services maintain or enhance, and do not diminish, the net accessibility, usability and compatibility of the City's existing environment and applications.

5.9.3. All documentation, user guides, training materials and services, and challenge response password and other identity-verification systems must meet the requirements. Contractor shall ensure that individuals with disabilities have access to the full functionality and Software Documentation for the product, including instructions, product information (including information accessible features), and technical support which is provided to equivalently authorized individuals without disabilities.

5.9.4. All subsequent updates, upgrades, bug-fixes and patches provided pursuant to the contract shall meet the Requirements.

5.9.5. In accordance with Cal. Gov. Code section 7405(b), Contractor shall have an ongoing obligation to promptly respond to and resolve any complaint regarding accessibility of its EICT products and services that is brought to the attention of Contractor, to the satisfaction of the City.

5.9.6. A failure to meet any of the requirements may result in rejection of the product or services by the City, withholding of payment, a complaint filed with California Department of Fair Employment and Housing (DFEH), a civil action, or other remedies, including, but not limited to, those provided in Cal. Gov. Code sections 11136 – 11139 and 12930, and this Agreement.

5.9.7. In the event of a conflict between accessibility standards, the highest standard will apply.

5.10. American Institute of Certified Public Accounts (AICPA) Audit Reports.

5.10.1. Contractor shall provide to City, on an annual basis, an SSAE 18, SOC 2, Type 2 Report, and an SSAE 18, SOC 1, Type 2 Audit Report, to be conducted by an independent third party ("Audit Reports") (if Contractor is using a hosting service provider, Contractor shall provide such Audit Reports it receives from its service provider or providers) as follows: (a) the Audit Reports shall include a 365 day (12-month) testing period; and (b) the Audit Reports shall be available to City no later than thirty (30) days after they are received by Contractor. If Contractor receives a so-called "negative assurance opinion," or the annual Audit Report finds a material data privacy or information security issue, Contractor shall notify City of such opinion within three (3) days of receipt by Contractor. Contractor shall implement reasonably required safeguards as identified by any audit of Contractor's data privacy and information security program or promptly notify City in writing if Contractor is unable to implement mitigation measures to address the issue(s). Upon any such notification, City shall have the right, without further obligation or liability to Contractor, to terminate this Agreement. Any failure by Contractor to comply with this Section shall be a material breach of this Agreement.

5.10.2. Audit of Contractor's Policies. Contractor agrees to make its policies, procedures and practices regarding Data Security available to City, if needed, and agrees that City reserves the rights, including, but not limited to, making a site visit, scanning for malicious codes, and hiring a third-party to perform a security audit if City determines that the Audit Report is unsatisfactory.

5.10.3. Information Security Audits. Contractor must contract with an independent third party to perform yearly information security audits of their primary and backup Data Centers. The annual audits must include an outside penetration/vulnerability test, and internal penetration and vulnerability tests with the third-party directly on the internal network. The summary results of the audits must be shared with the City. All audit findings must be remedied.

5.10.4. Audit Findings. Contractor shall implement reasonably required safeguards as identified by City or by any audit of Contractor's data privacy and information security program.

Appendix L

Reference Materials

Appendix L will be provided as a separate file.