Capitol Corridor Next-Generation Wi-Fi Solution

Conformed Statement of Work

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Capitol Corridor Joint Powers Authority
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1 Introduction and Objectives

1.1 Overview

CCJPA has procured, by the selection of Nomad Digital, Inc. (hereafter 'Contractor'), the future installation, testing, operation, and maintenance of a next-generation Wi-Fi network (the 'Solution') on board trains operated by CCJPA and their partners. The purpose of the Solution is to deliver (1) open Internet access over Wi-Fi for passengers, and (2) a secure on-board network to support business operations including a potential on-board and platform based passenger information systems all delivered from a service based model of delivery. The Solution shall also ensure CCJPA's wireless infrastructure and supporting systems represent the very best-in-class in terms of capacity, performance and operational reliability over the term of the contract through the application of a robust technical roadmap that shall be evolved over the term of the contract and allow upgrades to be sequenced onto the train fleets replacing obsolete systems.

This Conformed Statement of Work ('CSOW') outlines the tasks, requirements, and deliverables for the design, procurement, installation, testing, and operation and maintenance of the Solution, the core requirements of which include but are not limited to:

- The capability to utilize – where available – the latest generation of cellular technologies allowing the train-to-ground capacity to be maximized based on whatever the prevailing technical capacity is of the underlying networks;
- The provision of a network of links between rail cars to deliver a self-organizing backbone the length of a train consist, that is of sufficient stability and capacity to support passenger Wi-Fi traffic today and growth over time, secure segregation of passenger information services, and delivery of entertainment and other services in the future;
- A robust and fully-integrated suite of cloud-based back-office tools to configure, monitor and manage all elements of the on-board systems, provide detailed reporting of all aspects of the solution use over time, and detect and manage issues as they arise;
- Provision of a robust and flexible set of Application Programming Interfaces (APIs) both on-train and in the back office to allow third party access to key operational and technical metrics related to whole-system operation and usage.

The Solution shall include a service-based delivery model for all hardware, software, facilities, utilities, and labor necessary to meet the requirements, unless otherwise specified herein and any other components that may be identified as necessary, but subject to survey and confirmation by Contractor for specific Work Directives. CCJPA shall provide Contractor with Work Directives as required, and after review Contractor may provide comments and a service-based payment schedule associated with the Work Directive work scope and deliverables, for review and acceptance by CCJPA. Contractor shall be responsible for the supply of all required equipment and software; installation and commissioning of on-board systems on trains; set-up and maintenance of the back-office system; and ongoing upgrade of the Solution over time. The Solution shall be supported through a secure, cloud-based system that shall be capable of real-time monitoring and reporting on the Solution and its related services. As this is a service-based contract, all equipment furnished by Contractor during performance of the services shall remain the property of the Contractor.
This CSOW shall be used by CCJPA to define requirements for part or all of a Next Generation Wi-Fi solution on new and existing vehicles, and may also be used by other partner passenger rail agencies to procure similar solutions.

1.2 Strategic Objectives

1.2.1 Communications Platform

CCJPA is seeking a complete technology solution that will serve as a communications platform for Wi-Fi and other services aboard California InterCity Passenger Rail (IPR) trains and possibly other passenger rail partners. It is intended that Contractor will provide the solution as a fully-managed Finance, Design, Build, Operate and Maintain service to CCJPA where all costs are captured in a service-based monthly lease agreement with a commitment from Contractor to ensure that the system is upgraded over the contract lifecycle to reflect the latest technology developments.

The Solution will include robust onboard networking equipment and back office systems that together form the foundation to support the following primary services:

- Open Internet access over Wi-Fi for passengers;
- Secure, managed local area network (LAN) between IP-based systems installed within the rail vehicles;
- Mobile connectivity between the on-board LAN and remote back office systems to support rail business operations now and in the future.

1.2.2 Back Office Management

The Solution’s back office (see section 4.2 OSS Architecture) will provide real-time monitoring, management, configuration, and status reporting of onboard components, issue logging and remediation, and maintenance tracking. The back office will allow secure access to status, health, usage, availability, and performance raw data – both in real time and historically – through Contractor’s own tools and through APIs (see section 4.3 API Segment and Functional Description) that allow real-time and historic data to be gathered for analysis in CCJPA’s own tools.

1.3 Master Service Agreement and Work Directive Process

This document should be read in conjunction with the Contract Price Document (‘Pricing Document’), which contains the current prices for the components, software and related services that compromise the baseline system configuration as defined within this CSOW. The Pricing Document will be updated in conjunction with Contractor’s Product Road Map (‘Road Map’) to reflect the latest technology offerings of Contractor and how that impacts the Solution pricing.

This CSOW, the Pricing Document and the Road Map will be reference documents within a Master Service Agreement (MSA) that will form the contract between Contractor and CCJPA.

The MSA and this CSOW will not be considered a notice to proceed with any specific work. CCJPA will make use of a Work Directive (‘WD’) process under the MSA to inform Contractor of any work to be performed. Each WD issued by CCJPA, or its partners, shall include a Statement of Work (‘SOW’) with the specific requirements for that WD. Contractor shall provide a technical and commercial proposal in response to each WD. Upon agreement by both parties that the WD proposal is acceptable, a Notice to
Proceed (‘NTP’) shall be issued in the form of a Purchase Order. See section 3.3 Business Requirements for details of the Business Process to be followed for each WD.

Issued WDs may include services required to design, procure, install, test, operate, and maintain the Solution. In more detail, those services may include, but are not limited to the following:

- Project management and support;
- Requirements analysis;
- Solution design, development, and integration;
- Procurement of required materials and equipment;
- Installation & commissioning processes;
- Asset tagging and tracking of all installed Solution components;
- Testing and quality assurance in compliance;
- Training for installation, support and maintenance staff;
- User support, documentation, and user guides;
- Operations, maintenance, and tiered help desk support;
- Maintenance and annual update of cost pro forma sheets used in coordination with CCJPA;
- System data performance reporting and raw data sharing for all system usage, health and performance.

For each WD, Contractor shall propose a project schedule and submit to CCJPA for approval before NTP issuance. The approved project schedule will be incorporated into the WD.

For any rail cars on which CCJPA or its partners decide to install the Solution separate WDs will be issued to Contractor, which in turn will include a SOW. Contractor shall have the capabilities and resources to manage concurrent WDs in different locations, potentially across multiple fleets.

Specifications and diagrams for the train cars that shall be equipped with the Solution shall be made available to Contractor for each WD. WDs shall follow the Solution design and specifications listed in this CSOW as far as possible. However, each WD will define specific requirements, specifications, and design more precisely and, where needed, customize them on the basis of the train sets and area of train operation, and on the specific requirements of the route, service, and project. Any reasonable change in the requirements, specifications, and design shall ensure that functional and equipment interoperability is preserved across the entire fleet. All changes and additions to the MSA will be subject to CCJPA’s approval.

Where the requirements of a WD differ from the requirements of this document, with the mutual agreement of CCJPA and Contractor, and possible passenger rail partners, the WD requirements shall take precedence and Contractor shall be required to comply with the revised WD requirements (provided these are technically aligned with the Solution defined, rather than the requirements of this document).

Fundamental changes to Contractors solution or delivery process may be amended within this CSOW following a change management process.

2 Roles of Contractor & CCJPA

This section explains the respective roles and responsibilities of Contractor – and if applicable of its subcontractors – and CCJPA under this CSOW or on any specific WD issued as well as ongoing
maintenance and upgrades to specific components (hardware, software, firmware) over time. It also establishes the high-level principles with which Contractor and CCJPA will approach the delivery of the contract, and sets out the management structure that will be used by Contractor and CCJPA to report on and monitor WD deployments. For clarification, 'CCJPA' shall include officers and/or employees of CCJPA, Caltrans Division of Rail and Mass Transportation (DRMT), and CCJPA's appointed Wi-Fi Services team responsible for day-to-day management of Wi-Fi services and operations. If CCJPA forms a partnership with other passenger rail agencies that may wish to issue WDs under the MSA, by extension where CCJPA is identified in roles and responsibilities, there would also be a similar role for the partner passenger rail agency.

2.1 Contractor Roles and Responsibilities

Contractor shall provide uninterrupted project management services for the successful completion of all phases of the program which shall include, but not be limited to, planning, scheduling, coordination, risk analysis, communication, and complete documentation. Additionally Contractor shall:

- Deliver a Solution that is entirely fit-for-purpose for operation in a rail environment, and which complies with FRA regulations and with the specific technical and operational requirements of CCJPA or partner rail agencies (hereafter, where CCJPA is identified in context, if a future rail partner will act based on CCJPA's procurement, the partner's name can be generally substituted for CCJPA in the actions identified);
- Lead the design, solution development and deployment process activities and team meetings;
- Lead all operation and maintenance tasks with CCJPA's input, to CCJPA's satisfaction;
- Provide sufficient resources to provide for simultaneous deployment on multiple trains, and if required in multiple regions, as mutually agreed upon by CCJPA and Contractor;
- Obtain Contractor identification (badges) as required to gain access to maintenance locations;
- Follow CCJPA safety procedures in order to gain access to the site and support systems;
- Display Contractor identification at all times when on site;
- Abide by all safety standards imposed by CCJPA, the FRA and any local authorities or operating entities having jurisdiction;
- Acquire Permits To Enter (PTEs) from appropriate authorities, if required;
- When planning to enter the right of way or working in rail yards, attend all safety seminars and safety training as required by CCJPA or their maintenance partners;
- Provide suitable notice (recommended at least 21 days written notice) prior to entering or commencing work on railroad property, to a schedule mutually agreed on a case-by-case basis by CCJPA and Contractor;
- Where applicable on a WD basis, remove existing end-of-life (EOL) Wi-Fi solution components from all rail cars, and deliver such equipment to CCJPA at locations to be agreed;
- Perform all tasks listed in this CSOW and submit all deliverables listed under each task;
- Provide managed services for delivery and maintenance of a captive portal to which Wi-Fi users are directed upon connection to the onboard Wi-Fi network, and customize to CCJPA's or a State Partner's requirements, section 4.1.14.2 Captive Portal;
- Adhere to agreed-upon Service Level Agreements (SLAs) for Solution availability, performance and support response;
- Ensure SLA performance is reviewed quarterly through meetings of a Wi-Fi Steering Committee set up by CCJPA and its partners;
• Agree to exclude service-level performance parameters during time when agreed upon parameters are exceeded, or malfunctions are due to user error or negligence;
• Provide second level (Tier 2) support of issues that cannot be resolved by CCJPA Wi-Fi Services personnel and which are escalated to Contractor for investigation and resolution;
• Provide third level (Tier 3) on-site remediation by suitably-qualified staff of Solution issues when such issues cannot be resolved remotely by Contractor, or by CCJPA personnel or train crew;
• Manage all relationships with subcontractors, should there be any proposed;
• Assume full responsibility for all Contractor and subcontractors’ quality of work, performance, and timely delivery, and provide oversight of CCJPA-sourced labor as required by WD;
• Provide CCJPA with full access to any and all subcontractors for the purpose of evaluating performance, troubleshooting, and consulting on technical matters with representation from Contractor at discussions and meetings;
• Participate, as required, in meetings with CCJPA, and prepare status reports as required;
• Disclose information about the Solution design, development, deployment, operations, and maintenance, at CCJPA’s request;
• Provide automated access to the Solution’s operational status, performance metrics and other data as defined in this CSOW via processes and protocols including but not limited to one or more APIs, section 4.3 API Segments & Functional Description;
• Provide suitably-qualified resources with skills needed to accomplish tasks throughout the project lifecycle and ensure proper staffing and skills set needed to properly perform tasks;
• Identify Contractor employees who shall be considered key personnel for efforts under this CSOW or any subsequent WDs. These key personnel shall have an in-depth understanding of the requirements and their responsibilities as well as the ability, experience, and skills to perform the required tasks. Contractor shall designate key personnel and provide résumés to CCJPA for at minimum the following skill sets which shall be maintained with CCJPA as turnover or reassignment may occur:
  o Account Manager
  o Project Manager
  o Implementation Manager
  o Technical Manager
  o Solution Architect
  o Network Engineer
  o Systems Analyst
  o Requirements Analyst
  o On-Board Communications Subject Matter Expert
  o Operational Support Systems Subject Matter Expert
  o Quality Assurance / Quality Control Manager
  o Service Account Manager
• Follow predefined processes and provide all appropriate documentation for commissioning work to CCJPA prior to CCJPA-conducted per-car Solution validation, and roll out into production;
• Tag all assets deployed as part of the Solution, maintain an asset database that is updated each time a new or replacement asset is deployed, and provide automated access to the complete asset database via an API, or in the absence of an API via an alternative automated process if acceptable to CCPJA;
- Establish and maintain Configuration Management of software on all Solution components that are upgradeable, and follow an agreed plan for rolling out such updates as they become available;
- Provide full and detailed documentation and training sufficient to enable CCJPA to access and operate software provided by Contractor for the monitoring and management of the Solution on a WD basis.

When working on a WD, Contractor shall be fully responsible to:

- Identify the local and regional project requirements, and regulations to which Contractor is subject;
- Develop a plan that complies with these requirements and regulations that satisfies CCJPA;
- Ensure Contractor employees and subcontractors are in full compliance with such plan.

2.2 CCJPA Responsibilities

CCJPA shall be actively involved in the planning and deployment of the Solution, and of the applications and services it will support. CCJPA shall establish an interactive, participatory, and flexible relationship with Contractor. CCJPA shall:

- Provide information, personnel, and assistance during the planning and installation of the Solution and during its operation;
- Identify a Project Manager to represent CCJPA and be the individual duly authorized in writing by CCJPA to enter into and make changes to the MSA, and to make related determinations and findings on behalf of CCJPA and/or its partners;
- Provide project requirements on a WD basis;
- Provide timely and reliable access to data pertinent to the WD, and administer the flow of such data to ensure efficient communication between CCJPA, Contractor and its subcontractors;
- Provide instructions for safety training and rail yard general policies and procedures for Contractor personnel who shall be working onsite in CCJPA and other partners yards;
- Facilitate Contractor identification (badges) as required to gain access to maintenance locations;
- Determine the need for any type of safety service, as no work shall proceed at the site without proper worker protection;
- Support Contractor gaining access to rail yards, trains and other facilities as required by WD (subject to Contractor meeting appropriate insurance requirements and being issued PTE);
- Provide CCJPA labor where CCJPA deems its work force shall perform work for each WD;
- Provide sets of test requirements and processes sufficient for CCJPA personnel to fully and accurately validate the Solution after installation and commissioning has been completed by Contractor;
- Interact with the Contractor to process initial and annual updates to the cost pro forma sheet;
- Assume full responsibility for all CCJPA labor's quality of work, performance, and timely delivery;
- Assist in establishing and managing relationships with CCJPA departments and contractors as required;
- Provide maintenance facility and engineering assistance to Contractor and its subcontractors during the deployment and after the launch;
- Where applicable on a WD basis, provide facilities for the storage of end-of-life Wi-Fi solution components removed from rail cars;
• Provide a copy of CCJPA's and/or its partners safety procedures necessary to enable Contractor to conduct business at the site;
• Review and approve all project documentation related to this CSOW;
• Review and approve all Contractor documentation, designs, integration touch points, test plans and operation environments for all external services;
• Provide cellular data subscriptions and physical Subscriber Identity Modules (SIMs) to Contractor based on the best mix of networks determined on a WD basis;
• Provide project requirements to facilitate Contractor's development of the Service Level Agreement (SLA);
• Provide first level (Tier 1) service/help desk to which train crews and/or CCJPA personnel may report Wi-Fi service issues as they occur. The service desk will attempt to resolve issues but when unable to do so, will escalate to Contractor's Tier 2 support service for remediation, by phone or email depending on the severity of the issue;
• Work with CCJPA project management personnel to deliver task information or project tracking details in a timely manner as requested by CCJPA.
• When working on state partner fleets, direct or involve all communications through CCJPA and never solely with the state partner entity unless directed by CCJPA staff on a case-by-case basis.

2.3 Contractor Key Personnel

The key Contractor contacts illustrated in Figure 1 must be maintained and updated based on changes to project requirements and any personnel changes within the Contractor organization. All changes must be proposed to CCJPA and approved before being updated.
Figure 1: Organization Chart
3 CCJPA Requirements

3.1 Introduction

This section captures CCJPA’s minimum specific requirements relating to business needs, functionality, performance, installation, operation and reporting of the system. Contractor shall consider these requirements in the formulation of its concept design, baseline system configuration and product roadmap for new functionality. It is expected that these requirements shall form the basis of WD Statements of Work in the future.

3.1.1 Notes on Language

- Must / shall / will = mandatory requirement of CCJPA
- May / should = desirable requirement of CCJPA

3.2 Assumptions and Constraints

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Constraints
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<thead>
<tr>
<th></th>
<th>The Solution will conform to the space made available aboard trains.</th>
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<td>2</td>
<td>Cellular data connectivity may not be available from all carriers in all areas in which target trains operate. Where 4G LTE or better is not available, the Solution will automatically switch to alternative cellular data protocols e.g. 3G HSPA, EV-DO to maintain a data connection albeit with poorer performance.</td>
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<td>3</td>
<td>Train speeds may reach speeds of up to 79 miles per hour (MPH).</td>
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<td>4</td>
<td>Uptake of Wi-Fi service by passengers is typically very high compared to other modes of transportation, in most cases above 50% of riders on any given train set are expected to connect to the network.</td>
</tr>
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<td>5</td>
<td>Where tunnels exist, clearances are minimal, so the allowance for roof mounted antenna height is very small.</td>
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<td>6</td>
<td>The design of any new antennas installations on cars shall be limited to conform to height, wind speed, and other environmental restrictions on rail cars.</td>
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<td>7</td>
<td>No alteration or cutting of the car body shell shall be allowed to install Solution components, such as roof antennas, without prior written approval of CCJPA. Contractor will be expected to provide all design details and justifications for such modifications within a detailed design package, with supporting calculations as required, for analysis by CCJPA.</td>
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<td>8</td>
<td>Final testing shall be done on a train in service to verify that the Solution is functioning as expected and to the requirements of this CSOW.</td>
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<td>9</td>
<td>The Solution shall not produce RF interference that will affect other systems aboard trains.</td>
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<tr>
<td>10</td>
<td>Operation of new inter-car links and passenger-facing Wi-Fi access points must work in a variable consist, and be interoperable between all cars within a specific fleet as determined by WD.</td>
</tr>
<tr>
<td>11</td>
<td>Antenna placement on car roofs could be restricted by existing antennas using available space or by RF co-interference.</td>
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<tr>
<td>12</td>
<td>Any conflicts among specifications referenced must be brought to CCJPA’s attention for resolution.</td>
</tr>
<tr>
<td>13</td>
<td>Intra-Car RF pollution is very high due to passengers’ personal Wi-Fi hotspot devices and these devices compete for available bandwidth on the cell towers.</td>
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<tr>
<td>14</td>
<td>Equipment designed to run on DC power must have the ability to detect the loss of Head End Power (HEP) and shed their load from the DC bus.</td>
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</table>
3.3 Business Requirements

The Solution shall meet the following key business requirements of CCJPA:

3.3.1 General

The Solution shall provide a robust, IP-based connectivity platform for a train fleet. This platform shall be capable of supporting a number of applications that are either passenger or business operations oriented, and provide a secure method for CCJPA to manage all of these applications centrally with full visibility of the system operation.

3.3.2 Commercial and Business Rules

In all cases the WD’s will define the commercial agreement for any tasks however these should follow the principles defined in the sub-sections below.

3.3.2.1 WD Phases

Each WD shall be executed in a number of defined phases which may include, but not be limited to, the following:

- Initiation including design and development
- Materials Procurement and Vehicle Deployment
- Operations

Some phases may be merged together as required for each WD.

3.3.2.2 Service Model Billing

The monthly billing amount shall be based on the proforma pricing spreadsheet that will allow monthly billing to be calculated for each month spread over the contract period. Monthly billings are based on the Contractor’s own labor, materials and any other costs associated with project delivery. Each cost item (labor, materials etc.) will have an amortization period that is agreed within the WD response such that over time the monthly billings will reduce as that period expires for each element.

It is intended that for materials as the amortization period ends that the item will be replaced with a new part either to bring the system to the latest technology or for obsolescence management purposes. Billing can then be adjusted to accommodate the new parts monthly price and amortization period. If a part is not replaced at the end of the amortization period then billings for that part will be reduced by an agreed percentage to ensure that the Contractor can still maintain the item however recognizes that their capital costs have been covered. The percentage figure will be agreed in the pricing proforma for each part defined within the WD.
Within each **project phase** there will be an agreed number of **waypoints** identified within the project schedule that will define how many cars or other technical deliverables are completed. If these deliverables are not achieved in accordance with the project schedule then the monthly payments are deferred until the next **waypoint** when Contractor will have either caught up or further penalties then applied. If Contractor catches up and production deliverables are in accordance with the project schedule then the previously deferred payments are reimbursed.
This framework has been created to ensure adherence to the project delivery schedule and allow all parties to gauge progress at set intervals during the planning and execution of the work directive (WD). The framework enables CCJPA to withhold a percentage of the monthly payment based on the metrics scale outlined in the Waypoint(s) intervals which can then be reviewed and adjusted accordingly throughout the lifecycle of the project when the Crosscheck(s) interval are reached. The framework assumes that there are no delays in vehicle delivery or site access by which the contractor is entitled to claim charges that will be invoiced in accordance with rates indicated in the 3rd Party Contractor Labor Component and Nomad Labor Component tables in the proforma rate sheet.

- **Phase(s)** – key milestone in the project schedule that measures progress at a specified time in the lifecycle and outlines payment deferrals. It is assumed that there will be a maximum of two phases on any WD. Each phase(s) introduces as many way points as needed until the next phase(s) criteria. Phase(s) describe the criteria and percentages.

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### 3.3.2.4 Service Level Credits

Where Contractor fails to meet levels for availability of services as defined within the contract then service level credits will be applied against the Contractors monthly payments for that WD. Service credits are cumulative such that a single failure may impact the availability of multiple parts of the system and credits will be applied to each.

**Incident Resolution - Hardware and Infrastructure Failures**

Contractor shall resolve any Priority Level 1 or 2 incidents, as defined in Section 6.4 Service Level Agreement (SLA). If Contractor fails to meet the Service Resolution thresholds outlined within Table 1 within Section 6.4 in any month, then CCJPA will receive a credit equal to the applicable Credit Percentage shown below multiplied by the monthly charges for the month in which the failure occurred.
ONSITE Resolution SLA - Field Support

- All on-site resolution times are strictly dependent on availability of the vehicle or access to the site, as well as – in the case of rail cars – receiving accurate information from CCJPA regarding the intended location of vehicles at (and for) the times where Nomad’s Field Service Engineer is required on-site.

- CCJPA will be responsible for providing accurate schedule information and access to trains with adequate time to complete diagnostic, troubleshooting and any other type of work. Trains will be provided in safe, accessible locations with access to power (as required) and any other site safety protection.

- If the solution requires cables to be replaced, antenna on the roof to be maintained/replaced, on-train power issues, or an inter-car jumper issue to be resolved; then Nomad will escalate this issue to CCJPA for resolution. Requirements for second line support are as follows:
  - Train availability per CCJPA provided schedule
  - Power available on vehicle where needed
  - Vehicle in safe location
  - Sufficient time allowed to diagnose and perform work
  - Vehicle availability within 2 hours of scheduled arrival time
  - Equipment that is damaged by 3rd parties will be charged to CCJPA for replacement parts at the agreed price.

- Exclusions for SLA calculation
  - Planned downtime due to agreed system changes will be excluded from any downtime calculation.
  - Failures of the CCU system due to the loss of power or as a result of action taken by CCJPA or one of its agents will be excluded from any downtime calculation.
3.3.2.5 Work Directive Mechanism

A WD will be provided where there is a specific task to be undertaken on a fleet, for example, a new installation or upgrading a component. For example an initial WD will be issued for a fleet installation covering all services including service operation of the fleet. When an upgrade or replacement is due on a component then a WD will be issued to cover that work and changes to materials which will modify the billing defined within the original WD.

3.3.3 Scalability

The Solution shall be designed in such a way to deliver connectivity to a train set that is scalable in terms of throughput in downlink and uplink to meet growth in passenger and operational demand over a multi-year period. Similarly all other segments in the network between a passenger and the public Internet, such as links between rail cars and aggregation end-points in the data center, shall be designed to have sufficient capacity for such demand.

Where there are practical capacity limitations for any device or sub-system that forms the proposed solution Contractor shall clearly illustrate these and the overall impact on the solution. For example, the number of associated devices and maximum per client traffic for each access point. Figures shall be based on empirical testing and not theoretical values from hardware specifications.

3.3.4 Technology Evolution

Contractor’s overall design and solution components shall use a modular approach, and be adaptable for future enhancements and development in order to forestall obsolescence, and shall use commercially available off-the-shelf (COTS) hardware and software to the extent practical.

Contractor will provide and maintain a Road Map that projects forward a minimum of twelve months and defines both near-term product development tasks and medium to long-term aspirations. The purpose of this Road Map is to allow CCJPA and Contractor to plan system changes and upgrades, to ensure that the system continues to utilize the latest technology available based on market trends and CJCPA requirements, and replace components or sub-systems that have either reached the end of their usable life or are obsolete. The requirements of the Road Map are described later within this document (Section 3.5 Product Development Road Map & Upgrades).

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1 core connectivity services allowing the trains to communicate with the internet
Contractor shall clearly detail how the proposed solution offers CCJPA upgradability and expandability in terms of function and performance. For any system change undertaken on the fleet: hardware, software or configuration an impact assessment shall be undertaken to document and quantify the effect of that change on system performance or reliability.

3.3.5 Environmental Compliance
Contractor will have a documented plan that will show how the system is optimized in terms of efficient energy usage and what steps are considered in the procurement and disposal of hazardous materials throughout the lifecycle of the contract.

3.3.6 Cost Effectiveness
The Solution shall be cost effective through the use of innovations including but not limited to:
- A method of managing multiple SIM cards effectively to optimize cellular data subscriptions on the train and in the back office;
- Utilization of standards-based technology to ensure that there is a wider pool of system parts that can be deployed to upgrade the system at a later date and to simplify future upgrades;
- Cloud-based, back office operational support systems;
- On-board systems monitoring for advance warning and predictive analysis of mechanical and electronic defects, reducing the requirement for on-site visits by support personnel.

3.3.7 Consistency
All hardware, software and firmware comprising the Solution shall be consistent across all trains equipped by Contractor under separate WDs. For the avoidance of doubt Contractor shall not be responsible for managing any Wi-Fi solution not supplied by Contractor.

3.3.8 Open Access to System Data
CCJPA values very highly the ability to extract and analyze data from the Solution for a variety of purposes including but not limited to improved business intelligence across CCJPA operations, and the creation of data ‘dashboards’ within a CCJPA-managed analytics environment that cross-reference and compare metrics generated by disparate yet inter-relational systems for predictive analysis and trend monitoring. The Solution must support and be accessible by such dashboards to the greatest extent possible, using industry standard practices and protocols. Documentation and documentation sharing of key system design elements and dates of system modification must be shared with CCJPA/CCJPA’s Wi-Fi management team (or other rail partners), see section 4.3 API Segment & Functional Description.

3.3.9 Identification of Failed System Components
Contractor shall have a means to be automatically alerted if the Solution has any system component that has either failed or is not performing within defined levels. These alerts will be available to CCJPA in real time through an API to the monitoring system. Wherever possible the means used to create alerts will be able to filter out conditions that can falsely create a failure alert (for example if a vehicle is not in passenger service and can be expected to be off-line). Identification of failed or under-performing components is considered a critical aspect of Contractor’s solution.
3.3.10 Interoperability with Legacy Systems
WDs executed under the MSA may require a level of interoperability with legacy systems onboard a rail car and/or train set. Contractor may therefore be asked to provide a migration plan to facilitate such a transition while accepting that the intellectual property of both Contractor and the legacy system supplier is not compromised.

3.4 General Technical Requirements

3.4.1 Introduction
CCJPA has defined the minimum technical and operational requirements for the Solution, while encouraging maximum flexibility, creativity, and innovation by Contractor. This section summarizes each key component of the desired solution, and details the specific requirements for core features and functionality. The key technical requirements of the Solution are to:

- Use multiple cellular carriers to create a train-to-ground (T2G) connection of the best possible quality and capacity;
- Treat additional T2G links – including but not limited to satellite and trackside networks – as alternative methods of connectivity, if and when such links are installed on a train set;
- Create a high-capacity wired and wireless backbone throughout the length of a train with sufficient capacity to deliver an equitable level of service to each passenger rail car. The backbone shall comprise wired or wireless links delivering no less than 1 Gbps in any car from the location of the Internet connection (e.g. café car). The wired connection shall be considered primary and the wireless connection secondary, the latter providing redundancy in the event of wired backbone failure;
- Dynamically self-configure the on-board network when cars are marshaled together in a single train set or consist, while minimizing the risk of radio frequency (RF) interference between cars either from the inter-car links (if they are wireless) or passenger-facing Wi-Fi access points, and meshing between Wi-Fi-equipped cars in different consists;
- Enable any car from any relevant fleet to connect to each other and be interoperable, regardless of geographical location, route, or car type;
- Deliver Internet access over Wi-Fi using modern 802.11 standards to end-user devices, and ensure that coverage of the Wi-Fi signal is ubiquitous throughout every car in a train set;
- Provide Internet service over Wi-Fi to passengers, allowing common Internet tasks such as email, social media, connected apps, web browsing, VPN connection, and file upload and download (within CCJPA-controlled limits);
- Support the blocking of certain types of traffic based on content type and/or black/white listing;
- Provide on-board media storage for delivery of Wi-Fi landing pages or captive portal content including but not limited to static graphics and HTML, video, and audio in an industry accepted stack (e.g. LAMP) for delivery over Wi-Fi to end-user devices;
- Deliver a portal experience customized to a specific fleet, including but not limited to visual branding, Wi-Fi availability, and real-time trip information;

2 LAMP is defined as Linux, Apache, MySQL, PHP.
• Provide remote whole-system and individual component monitoring, analytical reporting, event recording and alerting, troubleshooting, and preventative maintenance capabilities;
• Comprise modular component kits for ease of installation and repair;
• Support migration to or incorporation of emerging technologies as they become available through the use of modular components including but not limited to storage, inter-car link radios (where wireless is used), digital train line (DTL), cellular radios, passenger-facing Wi-Fi radios, antenna and RF design, and IP routing methods;
• Provide back office systems in the cloud to reduce capital and operating costs and enable rapid expansion as the Solution is deployed across multiple fleets;
• Scale to provide a common communications platform using identical primary components for all installed fleets;
• Provide all system derived data to CCJPA as system service reporting and as ingestible raw data into CCJPA’s own data management system.

CCJPA is not committed to a specific solution or technology to achieve its business and/or technical objectives, but expects the Solution to use a sufficient combination of cost-effective wired and wireless interfaces and radio spectrum to provide maximum throughput, bandwidth, performance, coverage, redundancy, quality, and reliability. The solution should be capable of creating usable telemetry data to allow system operation, usage and health to be analyzed and monitored in detail through Contractor’s and/or CCJPA’s back office systems.

3.4.2 Notional Solution Design
CCJPA expects the complete Solution to comprise three core operational segments:

1. On-Board Network (OBN) segment, i.e. Solution components installed and operating in rail cars;
2. Operational Support System (OSS) segment, i.e. Solution back office components installed and operating in one or more cloud-based data centers 3.
3. System Data Access segment (API), data feed(s) and API available to allow access to system operational, health, usage and performance data.

The OBN segment comprises radio, antenna and ancillary equipment on the train that provides a cellular backhaul link and delivers Internet access over Wi-Fi throughout a train set. The technical and functional requirements for this segment are detailed in section 4.1 On-Train (OBN) Architecture and Functional Description.

The OSS segment comprises back-office systems for equipment and service monitoring and management. The technical and functional requirements for this segment are detailed in section 4.2 OSS Architecture.

3 For the purpose of this CSOW ‘cloud-based’ shall be considered a server environment that is not owned by either CCJPA or Contractor where services are made available on a lease basis to protect CCJPA from future hardware obsolescence and failure issues while providing a flexible platform to expand quickly with future services.
The API segment consists of a mutually agreed data structure and secure method of accessing real-time and historic data related to the system operation, health, performance, and client usage of the system. The technical and functional requirements for this segment are defined in section 4.3 API Segment & Functional Description.

Figure 2 illustrates the notional design on which CCJPA has based its assumptions to define technical and operational requirements.

![Diagram of On-Board Network (OBN)](image)

**Operational Support System (OSS)**

Traffic backhauled from a train over multiple commercial cellular links

Aggregated traffic over carrier and public networks

System Data Access (API)

Query of OSS and OBN real-time health status and performance, and export of all operational data to third party systems.

Communications system centrally located with Wi-Fi & Ethernet distributed throughout a train

Alternative backhaul e.g. trackside network

Aggregated traffic over cellular 4G LTE

Traffic backhauled from a train over multiple commercial cellular links

Cellular aggregation end-point, remote administration and monitoring at a hosted network operation center

**Figure 2: Notional Solution Design**

Referencing the acronyms shown in Figure 2, Contractor is required to provide a Solution that encompasses the OBN, OSS and API segments, while providing connectivity via commercial cellular data networks. Due to limitations of capacity and availability on a single carrier, CCJPA expects the Solution to utilize multiple carriers (e.g., Verizon, AT&T, and T-Mobile) to deliver the best possible level of service in any given area of train operation. The Solution shall support alternative backhaul links which may be implemented in the future at CCJPA's discretion, including but not limited to trackside and satellite networks, utilizing them where available based on CCJPA-defined commercial and technical rules.

### 3.4.3 Service-Proven Equipment

Contractor shall utilize service-proven hardware. For all parts and components, the Solution shall use designs that have a documented and satisfactory operating history, except where components or technology are so new that they cannot be expected to have a satisfactory operating history and which meet or exceed CCJPA's business and technical requirements as described in this document and its appendices. Contractor shall select and utilize high quality and reliable components, materials, and, as far as possible, proven designs that meet or exceed the referenced rail standards. Contractor shall provide product specification sheets for all equipment to be deployed, including replacements, upgrades, date of introduction, and possible dates for EOL support. All hardware will be tested against recognized industry and national standards, and manufacturers' Mean Time Before Failure (MTBF) data provided for CCJPA analysis. Systems and equipment with a limited service record shall be given consideration by CCJPA, but they shall be accompanied by presentations and engineering data containing sufficient information for CCJPA to review the merits of the design. Where Contractor proposes new hardware and/or software
features and/or functionality not previously deployed in a live rail environment, then the efficacy of such shall be fully supported by written evidence including but not limited to extensive lab/bench test processes and results to CCJPA's satisfaction. This requirement shall extend to future upgrades and/or Solution improvements during the contract term, whereby such changes shall be fully tested and ready for commercial adoption.

3.4.4 General Rail Standards Compliance

CCJPA requires that all Solution components be fit-for-purpose and suitably rugged for the rail environment, capable of withstanding shock, vibration, impact, humidity, atmospheric pollutants, dust and dirt intrusion, and ambient temperature as well as transient power fluctuations. Equipment located outside, such as train-born external antennas, must also meet requirements for survivability against corrosion, wind loads, object strikes, and other factors.

Contractor shall specify what industry and internationally recognized standards the components have been tested for and found to be in compliance with. In general, Contractor shall meet all requirements stated in the Code of Federal Regulation, Title 49CFR Part 238, and in the latest version of EN50155 as they pertain to on-board equipment. Contractor shall be and remain responsible for compliance with all applicable federal, state, and local regulations throughout the working relationship with CCJPA.

3.4.5 General System Standards Compliance

The system shall, wherever possible, follow recognized national or industry standards and/or codes of practice that define or guide system operation. This shall include, but not be limited to, the following areas:

1. Train IP network design and topography – IEC 61375 (various parts);
2. On-Board Multimedia and Telematic Systems – IEC 62580-1;

For all system areas Contractor shall identify where a protocol or process is proprietary, either directly to Contractor or from a sub-system supplier. The purpose of this is to make clear where there is any part of the system that may have to be replaced and/or upgraded in the future to ensure that it is clear how interoperable the system components are with a possible replacement.

3.4.6 Lifecycle & Continuity

While electronic equipment on rolling stock may have an operational lifecycle in excess of 175,000 hours, CCJPA accepts that certain components of the Solution – including but not limited to cellular and Wi-Fi radios – will advance during the Solution’s lifecycle and may require upgrade and/or replacement. Contractor shall identify what components are likely to require exchange over a five-year period, and specify the processes for accessing equipment that needs replacing. Contractor shall also specify Mean Time To Repair (MTTR) and Mean Time Before Failure (MTBF) ratings for core components.

System modularity and network agnosticism are key requirements of the Solution. Contractor shall accommodate future advances in radio and antenna technology, and keep CCJPA informed regarding the degree of complexity involved with upgrading the Solution, as upgrades are required. CCJPA wishes to minimize equipment service calls that could lead to potential operational downtime. To this end Contractor shall ensure the Solution can be remotely managed for in-field component diagnostics, and remotely updated with new configuration files and firmware in real or near real-time operations.
3.4.7 Network Cyber Security

The Solution shall provide a full range of security features to protect all Solution components from intrusions and unauthorized changes. This shall include, but not be limited to: firewall, encryption, secure SSIDs, and Layer 2 isolation.

Contractor shall provide a security design and methodology utilizing the following approach as an example:

- Risk assessment of vulnerability in accordance with recognized industry or national standards, for example: NIST 'Cyber Security Standards', IEC 62443 or equivalent;
- Provide system protection utilizing good practice perimeter protection methods;
- Undertake active anomaly detection on assumption that the perimeter protection can be compromised. This could include unusual network traffic, attempts to laterally move across network segments, and users running privileged levels of access. Anomalies that are to be detected shall be proposed by Contractor and agreed by CCJPA and these shall be reviewed, no later than an annual basis, and updated into the system operation;
- Monitor system operation to detect actual or attempted intrusion that will trigger an alert through the OSS;
- Contractor shall describe if and how the system is capable of automatically providing protection in the event that there is successful intrusion detected within the system;
- Security controls within the OBN shall not be dependent on the available of the T2G communication link;
- Contractor will include Layer 2 isolation within the OBN to ensure that it shall not be possible for any connected passenger device to see or communicate peer-to-peer with any other device on the wired or wireless network with the exception of the gateway and/or media server.

Contractor’s network security protection developments are maintained in the Product Road Map document section 3.5.

3.5 Product Development Road Map & Upgrades

Contractor shall provide a software and hardware development Road Map each year following contract award. This Road Map shall include a schedule of enhancements that Contractor shall be implementing in the upcoming 12-18 month period. The Road Map shall also include product logical architecture changes, physical architecture changes, and web service interface modifications. Contractor shall provide descriptions explaining each enhancement and an approximate time frame by quarter of when this enhancement shall be commercially available. The Road Map should align with incorporation on the active Pricing Document at the time, including tracking of hardware/labor/software/service support operating costs (as amortized capital costs).

Contractor shall provide CCJPA with maintenance releases of Contractor's base product software. Contractor and CCJPA shall mutually agree on the deployment schedule for updates, prior to any updates going into effect and Contractor shall provide documentation, training, and implementation support for all updates as necessary. The Factory Acceptance Test (‘FAT’) and System Acceptance Test (‘SAT’) configurations maintained by Contractor shall be upgraded first and tested. FAT and SAT results and analysis shall be provided for CCJPA approval. CCJPA reserves the right to reject any modifications, enhancements or upgrades to the Solution, at CCJPA’s discretion.
CCJPA is interested in a service-based commercial approach to Solution delivery that includes OSS and all OBN components installed on the target fleets. Contractor will be responsible for upgrading and replacing Solution components through the entire contract lifecycle, and billing CCJPA a recurring fixed service fee for the Solution as an alternative to upfront capital expenditure. Under this approach all Solution components implemented through a WD shall have a defined Usable Life that will be proposed by Contractor and approved by CCJPA. The Usable Life is the shortest of:

1. The time that a component can be reasonably be considered to be effective following date of installation, and
2. The time by which new technology will be commercially available and a performance upgrade should be undertaken to ensure that the Solution is performing optimally.

For each component that reaches its agreed Usable Life the Contractor will present options to CCJPA for upgrade or replacement including anticipated performance gains or other improvements. Contractor will provide a detailed impact study of how the new component(s) can be integrated within the current system while minimizing any detrimental effects on the Solution operation during the process. Any additional Service Cost fee for the component replacement and implementation will be provided by Contractor together with the new Usable Life of the new component for approval by CCJPA.

Only under particular circumstances will CCJPA consider it acceptable that any component with an agreed Usable Life is not replaced within that time. In most circumstances this will be considered a breach of contract and will be managed through that process.

In addition to Contractor-proposed upgrades, CCJPA may request specific enhancements to the Solution. Contractor shall develop procedures for tracking, prioritizing and scheduling these requests. Contractor shall define and formalize how CCJPA shall request changes to software, and work with CCJPA to determine the best path to implementation. CCJPA will reserve the right to reject any software that does not fully meet previously agreed-upon requirements.

Contractor shall provide within the Product Road Map a breakdown of technologies that relate to this CSOW and for each provide a narrative explaining what is currently available in the market, and if it has been approved and deployed in a rail environment. The narrative shall include a critical analysis of the impact the latest product evolutions have within the railway environment. This may include, for example, the migration to 802.11ax Wi-Fi access points, and Category 11 LTE cellular modems.

Contractor shall attend a Product Road Map meeting every six months, as part of their operational support contract, with CCJPA to present Contractors current roadmap. The purpose of this is to discuss areas of the Solution that may approaching the end of their usable life, and mutually decide what options are available to either (a) replace with an equivalent, or (b) upgrade to the latest relevant technology. CCJPA will also use this forum to propose additional services for passengers, or make improvements to other train systems using technology that may be part of Contractor’s core solution, or that can be integrated from suitable partners. The concept is that CCJPA should not be deploying equipment that is more than nine (9) months older than would be what the Contractor would commercially deploy on a new system so that the usable life of the equipment is maximized for the install period.

Subject to applicability and other constraints CCJPA intends to have the on-train system utilizing technology that reflects the latest available from Contractor but that has been service proven for no less than nine (9) months with another comparable customer.
3.5.1 Deliverables for Product Road Map and Upgrades

The deliverable documents required for Product Road Map and Upgrades are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Development Roadmap and Upgrade Plan</td>
<td>Software roadmap for 18 months ahead as PowerPoint in PDF format.</td>
</tr>
<tr>
<td>Hardware Development Roadmap and Upgrade Plan</td>
<td>Hardware roadmap for 18 months ahead as PowerPoint in PDF format.</td>
</tr>
<tr>
<td>Technology narrative</td>
<td>Explanation of current industry trends and how these may or may not be adopted in Contractors roadmap.</td>
</tr>
<tr>
<td>Enhancement Request Procedures</td>
<td>Written description and process for requesting software or hardware enhancements.</td>
</tr>
<tr>
<td>Training &amp; Documentation</td>
<td>Documentation, training and implementation support for all updates as necessary.</td>
</tr>
</tbody>
</table>
4 Solution Architecture & Functionality

This section provides a general overview of Contractor's Solution architecture, identifying the various components that comprise Contractor's end-to-end solution and the system's high-level functionality and characteristics. The solution architecture is not expected to change significantly between Task Orders and represents the baseline design and functionality of the OBN and OSS components. The Solution architecture concept is largely expected to stay similar in nature however individual components, operating together as the system, are expected to be replaced over the useful life of their operation according to the product road map (see section 3.5 Product Development Road Map & Upgrades) and as reflected in the Pricing Document.

4.1 On-Train (OBN) Architecture and Functional Description

4.1.1 Overview

CCJPA's general system architecture for on-train communications is built around a core IP-based intracar, intra-train and train-to-ground technology. All of the Solution components that are installed onto the train form the On-Board Network (OBN) segment. The OBN can then support a range of passenger-facing and operational applications which utilize this IP infrastructure. Figure 3 illustrates the generic OBN architecture that would be deployed to CCJPA train fleets.

![Figure 3: On Board Network (OBN) Architecture](image)

4.1.2 Location of OBN Components

An existing Wi-Fi solution installed on California IPR rail cars, and other CCJPA partners' fleets, uses a centralized model whereby the core components e.g. the mobile router, cellular modems, RF multiplexers, and roof-mounted antennas are located on a single car. On the California-based fleets this is typically the café/diner car, while on other fleets it can vary between different car types. CCJPA prefers to retain this centralized model to reduce the impact of external work on rail cars, for example when installing roof antennas, and for a Next Generation Solution to utilize the space made available...
following removal of the existing Wi-Fi system. It is anticipated that the different solution architectures may be required to meet specific technical requirements of fleets, for example where more than one router is installed within a train consist, these requirements shall be defined within specific WD’s as required.

4.1.3 Mobile Router Hardware

As a minimum the following CompactPCI blades will be available for the router:

Contractor’s mobile router technology (hardware) are maintained in the Product Road Map document as defined in Section 3.5.

4.1.4 Mobile Router Software

CCJPA expects the main purpose of the mobile router will be to act as the gateway between the train and the Internet. The router will be capable of managing multiple cellular connections from different mobile network operators and allow the bandwidth available from each connection to be aggregated to maximize bandwidth between train and shore or use a cost/prioritization scheme to allow different data to utilize different connections based on rules agreed with CCJPA.

The router shall deliver the best possible T2G connection at any given moment, and this shall be accomplished through a Contractor-specific method of link bonding, aggregation or other technique. CCJPA accepts that Contractor cannot warrant the availability or performance of commercial cellular
networks as these are outside its control. Nevertheless as the quality and performance of the T2G link is 
paramount to the successful delivery of Wi-Fi service, CCJPA requires the Solution to take into account 
mobile network coverage and quality variations between mobile operators, and employ the combining and 
optimization of – and seamless switching between – multiple 4G LTE cellular links.

The mobile router will provide the following key functions:

1. Optimized T2G communication by aggregating the bandwidth that is available from a number of 
cellular modems, or other communication technologies, to make this available to all passengers 
or other subsystems connected to the Solution. The solution will determine what cellular capacity 
is available from each network and be able to apply rules to direct specific data over different 
networks by priority/cost or other rules. The intention is that all data capacity (less operational 
overhead) will be available for passenger devices and other on-board systems;

2. Provide a platform that can support the deployment of third party applications onto the router 
either as Virtual Machines (VMs) or within containers. This architecture will be a managed 
environment where resources required and used by the other applications will be controlled to 
prevent over use of available processor and/or memory resources and will not disrupt other 
applications running on the same platform;

3. Provide Authentication, Authorization, and Accounting (‘AAA’) services for passenger devices and 
other systems as required that may be connected to the train network;

4. Ensure data security is maintained for all devices that are connected to the train network 
considering all the requirements defined within section 3.4.7 Network Cyber Security;

5. Host a landing page or media portal that can be updated centrally and delivered to passenger 
devices supporting a range of rich content including media that uses Digital Rights Management 
(DRM);

6. Maintain a robust set of APIs that will allow the secure sharing of common data (e.g., GPS 
location and time) as required between systems connected to the on-train network (see section 
4.3 API Segment & Functional Description for API details).

Contractor shall ensure that all Mobile Routers deployed on California IPR vehicles are maintained with 
the identical router software at all times. Contractor’s mobile router software developments are 
maintained in the Product Roadmap document.

4.1.5 Cellular Modems

The Contractor will maintain a range of cellular modems that are certified by the US cellular carriers and 
can be implemented within the mobile router to optimize T2G backhaul. Currently 3GPP standards
describe modem categories that define the maximum throughput that can be achieved from a cellular modem. Devices have to be:

- Available in a rugged format suitable for the application environment;
- Certified by the cellular carrier;
- Integrated within the mobile router by the Contractor;

As of February 2019 Category 6 modems are certified and available for use in the US market. (See roadmap document sections 1.1 and 1.2)

Contractor's Product Road Map will maintain a clear list of all modems currently in process of Contractor integration and carrier certification that will allow new devices to be assessed and integrated into the train platform when available and/or the existing modems are end of life.

 Contractor's controller architecture makes provision for two modem replacement scenarios:

- The controller hardware can support significantly higher throughput than current modem devices require, to allow for future enhancements;
- This model allows even greater flexibility to support future network expansion but may also impact the design of future roof antenna installations.

An upgrade of the on-board router platform from existing 3G/4G technology to upcoming 5G technology, may impact the following elements which will be addressed on a V&D basis:

- Modern modules installed within the on-board router;
- Coax cabling between the modems and the roof-mounted antennas;
- Roof-mounted antennas;
- Hybrid combiner and splitters used between the roof-mounted antennas and modems.

Contractor must ensure that the platform maintains compliant with US legislation, for example PTCRB, when new technologies are introduced. The solution applied under the service model is designed to ensure that the latest commercial technologies incorporated by the Contractor, and referenced within the Product Roadmap are used in service delivery.

4.1.6 U.S. Carrier Mobile Network Certification

Devices such as mobile routers that contain modems using SIMs for U.S. mobile networks are required to be certified as a 'whole system' by each carrier whose network the device uses. For example, a router containing a modem compatible with Verizon and using a Verizon SIM must meet Verizon conformance requirements, device testing, and certification processes before they are certified for use on the Verizon network. This is the case regardless of whether the individual modem has been certified separately.

Contractor shall ensure 'whole system' certification for the Solution for each U.S. carrier on whose network the Solution is intended to operate.
4.1.7 Interoperability with Alternative T2G Links

While CCJPA expects cellular communications to remain the primary method of T2G connectivity for the majority of fleets, the ability to interoperate with alternative technologies is an important feature of the desired Solution. The Solution shall have the ability to work with such alternative links, and intelligently select the most appropriate connection based on predetermined business rules such as least-cost routing, and technical criteria that will include but not be limited to network availability, order of prioritization, signal strength, modulation scheme, throughput, latency, and other measures of link performance and quality.

4.1.8 Roof Antennas and Connection to Cellular Modems

Optimal performance of T2G links is challenged on many levels by the mobile networks themselves. Operators have not located base station sites with delivery to trains in mind; as a result, sites are often some considerable distance from tracks, and even where masts are close, antennas may not be pointed towards the right-of-way. Coverage issues are compounded by contention for base station capacity by users in residential and business areas, and by passengers on a train who choose to use cellular data devices such as personal hotspots during their journey. Therefore the design and positioning of roof-mounted antennas, and their functionality with individual modems, must take these challenges into account for the best possible RF performance.

Generally speaking, it is preferred to keep the need to penetrate the outer skin of a train to a minimum. All new antennas must remain with the dynamic gauge envelope of the target vehicle which will be provided with the associated WD. Contractor shall note that static and dynamic gauge envelopes vary between car designs and fleets therefore a single roof antenna design scheme may not be applicable across all car types, and variations may be required on a WD basis.

Contractor proposes that a generic system design

These can be directly connected to allow two RF connections per modem or passed through hybrid combiners to provide four connections per modem. Contractor will need to undertake analysis of how many modems would need to be supported inside the mobile router and as such how many antenna connections are required. In general roof-mounted antennas shall:

- Use an CCJPA-approved, Amtrak approved, and most importantly for the California owned cars, Caltrans approved, method of mounting to the car body;
- Be water resistant, and support wind speeds in excess of 300 MPH;
- Withstand impacts of 4G vertical, 4G lateral and 8G longitudinal (direction of travel);
- Withstand corrosion caused by diesel exhaust contaminants;
- Withstand impact of objects, debris and small animals at speed;
- Withstand interference from overhead electrical catenary, where such catenary exists;
- Withstand harsh environmental conditions and comply with the latest version of European Standard EN 50155 for temperature and humidity category T1.

4.1.9 Access Points

Contractor's Access Points in use are maintained in the Product Roadmap document section 1.5.
4.1.9.1 RF Configuration

Each car shall have a minimum of one Wi-Fi Certified passenger-facing access point (‘AP’) providing sufficient RF signal to cover all parts of the car that a passenger or train crew can be expected to occupy in normal operation, with a strength not less than -70 dBm and a signal-to-noise ratio in the range of 25-30 dB.

At minimum the AP shall contain Wi-Fi radio supporting end-user devices at 802.11a/g/n at 2.4 GHz, using channels permitted for use in the United States. Please note that APs shall be configured to reject network association by legacy 802.11b passenger devices to avoid the negative impact on network performance.

APs will be used that will provide both passenger Wi-Fi connectivity to the on-train network and an optional car to car wireless link between adjacent vehicles (as described in section 4.1.11 Car to Car Connectivity). Each AP will incorporate two internal radio modules, one in each of the 2.4 or 5 GHz bands. If implementing a Wi-Fi car-to-car link then typically a 5 GHz radio would be used leaving the other radio within the AP to provide 2.4 GHz connectivity for passenger devices. Subject to RF survey within the cars additional APs can be provided to provide better RF coverage and minimize areas within the passenger areas with poor coverage.

4.1.9.2 Service Set Identifiers (SSID)

CCJPA requires that it shall be possible to identify and prioritize traffic both from different APs and when connected to a different SSID. It shall be possible to have multiple SSIDs concurrently configured per AP that are set with different parameters such as visible or hidden. The SSID name(s), visibility, and possible Pre-Shared Keys required by CCJPA shall be defined within the specific WD for a fleet deployment.

4.1.9.3 Access Point Management

This reduces the reliance on T2G connectivity when updating the software on a train fleet limiting the bandwidth demands and also de-risking any upgrade process.

4.1.9.4 Wireless Intrusion Protection

The APs provide a security function by periodically allowing one of the passenger facing AP radios to switch out of passenger mode and instead scan the local RF environment. The purpose would be to search for rogue devices that could be trying to spoof passengers by providing a false SSID mimicking the one provided by CCJPA.

4.1.9.5 User Connection Seamless Roaming

The AP – either by the configuration of radio power, utilizing a roaming protocol, or a combination of these – shall ensure that when a user device makes an initial connection to an AP in one car and subsequently moves through the train to another car, it shall transfer gracefully so that the connection is...
moved to another AP that offers a better link based either on proximity or AP loading. Even if the first AP is still visible to the connecting device it shall be automatically re-associated to the new AP without affecting the user experience. In summary, the Wi-Fi experience and delivery of content shall not be interrupted in the event that a passenger moves around the train in the course of a journey.

4.1.9.6 Future Standards and Development
Contractor shall describe within the Product Road Map if and how emerging Wi-Fi standards and technologies are being considered, and the timeline to implementation of new features.

4.1.10 Ethernet Switch
Subject to functional requirements each car will be provided with one or more Ethernet Switches (‘ES’) that will be used to provide connectivity and power to on-board to AP’s and other devices. These should compatible with any existing Digital Train Line (‘DTL’) switches and would interoperate with them during any installation program. All switches installed on California IPR trains shall be capable of being monitored for availability and health status in the back office tools.

4.1.11 Car to Car Connectivity
It is expected that most vehicles that will be implemented with the Solution under different WDs will comprise cars that are not formed into fixed train consist, but are variable in that individual vehicles can be added or removed on a daily basis with no reliable back office system to notify what a consist is or should be. As a result the Solution must dynamically auto-configure without any manual intervention to establish and maintain car-to-car network communication as cars are coupled and decoupled from a train set. While a fixed consist train will not have the same issues the system architecture should be capable of recognizing the exceptions where a vehicle has been removed and replaced with an alternative and either flag for manual intervention or automatically re-configure the network and associated data reporting.

The Solution shall be capable of reporting to the OSS inter-car link (‘ICL’) status and configuration including but not limited to power level, throughput obtained over time, modulation scheme, channel assignment on a per car basis within a consist, and alerting the OSS to issues arising from failure to establish or maintain inter-car links. The actual consist arrangement, car order and orientation shall be data that is available both to other systems within the train through an API and also off-train to support reporting and analysis. The Solution shall support a consist-wide Ethernet network where data can be passed through the train length and the network managed as a single network. The Solution shall have options to utilize either wired or wireless links between adjacent vehicles.

4.1.12 Wired Connections
For a dynamic consist where vehicles will be routinely separated and may be re-formed into a new train then a wired network in accordance with PRITIA 305-919 Digital Train Line shall be implemented. This standard defines the hardware architecture for such a network to ensure physical interoperability with other similar vehicles.
Trains that operate as a fixed consist or multiple unit that are never or only rarely split and re-formed and also never interoperate with other vehicles may utilize a physical connection that is less suited to rapid connection and disconnection and other associated constraints.

The wiring for any wired connection between vehicles will use Cat 7 Ethernet cable and interface connectors that are certified to operate at speeds of 10Gbps.

### 4.1.13 Wireless Connections

#### 4.1.13.1 Wi-Fi Connection

The Solution may implement a wireless car-to-car connection using a Wi-Fi wireless connection from the AP described in section 4.1.9 Access Points. This will utilize as a minimum an 802.11ac connection or as technology improves an alternative protocol to achieve a data connection between adjacent vehicles. The antenna used for this connection will be either mounted to the external vehicle body or within the vehicle using the car-end vestibule to pass the signal from car to car. The choice and location of antenna will be determined by physical and RF studies within the train consist.

In any WD response that requires a Wi-Fi based connection between cars Contractor will describe how wireless channels and transmission power levels will be selected automatically to ensure that immediately adjacent radios within the same train set are operating on the same channel and that other links use different channels to reduce the effect of in-band interference on the system performance.

#### 4.1.13.2 60 GHz Radio Connection

As an alternative to a Wi-Fi connection between adjacent vehicles and based on functional requirements a higher speed connection may be implemented using a 60 GHz radio based on 802.11ad technology. This offers the following advantages:

- Gigabit connection speeds;
- Short range meaning that connection to adjacent trains is ruled out;
- Immune to interference from the already widespread usage of 5GHz and 2.4Ghz bands.

The 60 GHz equipment comprises of an indoor unit (IDU) which is attached to the Ethernet network and an antenna which must be mounted outside the car with only free air between the antenna and its counterpart antenna on the opposing car.

### 4.1.14 On-Board Passenger Experience

#### 4.1.14.1 Bandwidth management

To maintain a satisfactory user experience the Solution employs dynamic bandwidth allocation per user, and traffic shaping to prioritize or throttle bandwidth in the downlink and/or uplink for certain types of data-intensive traffic such as large file transfers. The Solution implements content filtering (e.g. pornography and other explicit content), URL and IP whitelist and blacklist, and of restricting or blocking certain background activities such as streaming video and audio, OS updates, and cloud-based back-up, while also limiting access on a per user or device basis.

- URL blocking is provided within the data center by blocking access to either specific objectionable sites or categories of sites.
4.1.14.2 Captive Portal

The Solution shall use a mechanism to display a captive portal or ‘splash page’ the first time a user connects to the Wi-Fi network during a given journey; this page shall be hosted on the on-board the train (e.g., on the mobile router) so that passengers receive content with least delay. The captive portal shall be customizable for specific fleets on a WD basis. CCJPA may wish Contractor to undertake portal design for each WD, or require Contractor to provide sufficient design guidelines to CCJPA to allow this page to be designed by a third party and function seamlessly within Contractor’s Solution.

Wi-Fi end-users shall be required to read and agree to a CCJPA-provided document Terms and Conditions of Use prior to accessing the Internet, and be required to click an ‘I agree’ button to verify their acceptance. The action of accepting the Terms and Conditions shall be recorded and stored with other session information. The captive portal shall be capable of scaling to work with a wide range of devices including laptops, tablets and smartphones with appropriate versions for each device type. Using the latest authoring technology for responsive web sites, the portal shall function with a variety of end-user device display mechanisms including the most popular web browsers, and be configured to block captive network assistants (CNAs) such as that found on MacOS which display portals automatically in a non-browser environment. The user shall not be required to re-authenticate unless the Terms and Conditions change, or within an CCJPA-defined timeout period. CCJPA may require that authentication is handled differently for a device that has already authenticated on a different train within a set period, Contractor will describe how this can be achieved within the system.

After accepting the Terms and Conditions, the user will be presented with a ‘landing page’ branded on a WD basis and customized by fleet, which will notify the user that they are connected to the Internet. The captive portal shall have a mechanism for users to test their Internet connection to (a) verify that the Internet is available, and (b) see the available downlink and uplink speeds. In the event that the T2G link is down for whatever reason and Internet access unavailable, the captive portal shall display a message to this effect, notifying users of a temporary interruption, until normal service is resumed. CCJPA may have additional functional requirements that Contractor shall implement on a WD basis. Contractor shall be responsible for ongoing content update, maintenance and support of the captive portal.

The Solution shall deliver via any passenger-facing Wi-Fi AP a fully-loaded Terms and Conditions page with one second of page request while the train is in motion, with no less than 20 active users on that Wi-Fi AP. Contractor shall validate through load testing within a lab environment prior to first train installation. All portal pages shall use Google Analytics (or equivalent) for user traffic tracking and reporting, with the relevant Google Analytics account made available to CCJPA.

It shall be possible to scale the portal to provide an enhanced version which includes the provision of rights-managed media content, e.g., digital magazines, movies and TV shows. Contractor should provide detail in their response on how this may be delivered, including technical and commercial arrangements, possibly on a pilot basis. Where there is a requirement for a custom application (app) to be used on a tablet or phone to support digital rights-managed content then this shall be described together with what level of custom development will be required. CCJPA prefers if this can be implemented without passengers requiring a specific app on any device.
The captive portal presented on California IPR trains shall be capable of being monitored for availability and health status in the back office tools. Contractor's portal and media solution planned releases are maintained in the Product Roadmap document sections 2.1 and 2.2.

4.1.14.3 VPN Support

CCJPA's existing Wi-Fi system supports use of VPN connections by end-users who may wish, for example, to connect remotely to corporate networks that require tunneled, encrypted connections. Unfortunately, use of VPNs also enables passengers to bypass processes imposed by CCJPA to ensure equitable Wi-Fi use, such as content restriction and bandwidth controls. For example an end-user may use a VPN to stream Netflix, a service which is normally blocked by the Wi-Fi system to mitigate network congestion. CCJPA wishes to implement a mechanism whereby corporate VPN connections are permitted while unfair use of those connections is not. Contractor shall outline how the Solution shall enable content controls and fair use of available bandwidth while permitting legitimate use of VPN connections. Contractor shall also identify methods by which VPN connections are maintained when switching between cellular links, and/or where links may be of variable quality.

4.1.14.4 User Session Record Keeping

The Solution shall be required to log end-user device MAC address, session start and end times using RADIUS or some other method, and be capable of reporting to the OSS metrics including but not limited to user device type, operating system, browser version, passenger location based on AP ID and/or GPS, session duration, data volume transferred up and down during the session, URLs visited, and time spent on a page. Session time shall be considered to be from when the device connects to the network and accepts terms within the system to connect to the internet (or to view content) and shall be considered completed when their data rate reduces to less than 50kbps without recovering later on the same journey. This is in preference to other metrics, for example, DHCP lease time.

The system shall also report Wi-Fi network traffic information including protocol, and source and destination IP address and port.

4.1.15 Virtual Networks & Future Expansion

When planning the train backbone network, Contractor shall take into account future applications that may increase demand on the network for intra-train use. For example, delivery of video and audio content to passenger devices from an on-board server; video from cameras for operational and security purposes; and media for CCJPA's On Board Information System (OBIS). The Solution shall support 802.1Q Tagged VLANs to securely separate these multiple sources of traffic, and enable prioritization based on traffic type and/or CCJPA-defined rules.

It is anticipated that systems requiring audio and video streaming (e.g., OBIS and on-board entertainment) may utilize multicast channels to transmit data through the train. Contractor will ensure all components that make up the OBIS are capable of handling multicast traffic and also any constraints that may need to be considered.

4.1.16 System Watchdog

The Solution shall provide watchdog features where an unresponsive router will be automatically rebooted after a configurable time and under conditions agreed with CCJPA. The watchdog shall be
4.1.17 System Audit

The system will routinely self-audit OBN components to determine any anomaly in firmware or configuration of any configurable device. The audit data shall be generated whenever a device is discovered by the Solution, or at a minimum once per day, and compared with the known current platform as agreed through the system design and change control process. The audit data shall be available by API and also reported within the OSS to provide system traceability for all components. The data shall be available for all individual devices, for design locations on a rail car (i.e., where devices are mounted), and for the history of component hardware, firmware and configuration.

4.1.18 Availability

During periods when a train is in revenue service i.e., carrying passengers during normal scheduled hours, the Solution shall provide passenger Wi-Fi service in respect of the carriages served with excluding cellular carrier network availability and performance.

4.2 OSS Architecture

4.2.1 Overview

The Operational Support System (OSS) provides day-to-day monitoring and management of the OBN and constituent components, while also providing an end-point for all aggregated T2G links from trains, and access to the Internet. The system shall receive data from the train-based OBNs to provide a real-time and historical view of system activity, system component status, health, train-to-ground network performance, and other key indicators. Furthermore, a proactive approach to condition monitoring, with an effective process for alerts and problem escalation, will enable issues to be detected and resolved before they have an detrimental impact on the passenger experience. Condition monitoring shall not require on-train/in-service personnel (e.g., conductors) to play an active role in identifying Solution issues, and those personnel shall only be involved if Contractor or CCJPA identify a simple solution that is most easily and cost effectively addressed by a crew member. In such circumstances the CCJPA Wi-Fi Services team would be contacted to initiate such action.

The OSS and its features shall be accessible by CCJPA personnel 24/7/365 on a tiered access model through a secure web-based, self-service portal for desktop and hand-held devices, with a GUI appropriately formatted for such devices. All OSS components shall be accessible via a single sign-on (‘SSO’) process, without the need to access different systems for different data. All components of the OSS shall be graphically designed with a common user interface and look-and-feel, regardless of whether data is being derived from different sources. The system shall be fully managed by Contractor on behalf of CCJPA, be hosted as a cloud-based service with a level of redundancy specified in 4.2.2 Hosting & Redundancy, and support concurrent use by up to fifty (50) support personnel. Contractor will clearly describe if there are specific license requirements on a per user basis for system access.

Contractor’s planned OSS developments are maintained in the Product Roadmap document section 4.0.
4.2.1.1 Real-Time Status
The ability to monitor via the OSS, the health, condition and status of the Solution and its constituent parts wherever deployed is extremely important to CCJPA. This includes all aspects of mobile router operation including but not limited to cellular links (and other T2G links as applicable) and their current and recent status, performance and quality by device ID, by train set and car number, or by route service number; data usage by carrier, modem and SIM ID, and trending to predict cumulative data usage by SIM ID within a pre-determined billing cycle; and events that impact the availability of Wi-Fi service to passengers as they occur. Contractor shall fully explain all aspects of the Solution's real-time status monitoring capabilities, including identification of issues with inter-car links and passenger-facing APs. All such data generated by OBN and OSS segments shall be available for sharing with CCJPA's own back office systems using an API and other processes mutually agreed by CCJPA and Contractor.

4.2.2 Hosting & Redundancy
The OSS shall guarantee an extremely high level of system availability and a rapid response time to support issues. CCJPA requires a hosted OSS solution with all components accommodated by Contractor in a suitable cloud-based service provider that is compliant with industry standards for security and availability, and provides redundancy through mirroring of essential services i.e., multiple instances. CCJPA must approve the proposed cloud provider(s) and system configuration. Contractor will describe how the requested availability will monitored and achieved for all OSS system components, and how CCJPA will have on-demand access to the availability (e.g., system uptime) statistic in real time via an API and other means.

CCJPA expects, via additional WDs, to expand deployment of the Solution on multiple fleets in multiple geographic regions, in some cases in conjunction with rail operating partners in states outside California. Where this is implemented virtual data center locations shall be available located strategically around the U.S. to minimize latency between trains and aggregation end-points. The OSS shall allow separate fleets to be segregated so that system and performance data can be viewed for individual fleets only by specific users or all fleets by other users. In all cases, such segregation shall be respected and supported by the OSS API.

4.2.3 Central Network Services
The back office elements of the Solution proposed are collectively termed 'CNS' (Central Network Services) and comprise:
CNS is the central point where all the fleet traffic converges. Its overall architecture is detailed in Figure 4. All IP-based elements of the CNS shall be capable of being monitored for availability and health status in the back office tools.

Figure 4: CNS Architecture

This comprises the "traffic pipelines" where the passenger traffic goes and the "services area" where the service traffic goes and where the servers for centralized services are hosted.
whose role is to provide the backend service for network supervision. Network supervision is performed through a web application called NMS which queries the NOC server to get and present the relevant supervision data. Provided by the Contractor’s hosting provider.

4.2.4 Internet Connectivity
The Internet connectivity of the CNS is maintained by Contractor’s selected hosting provider. Within that virtual environment, the CNS connects to the Internet using:

- [Bullet point]
- [Bullet point]

Where Contractor’s Solution routes aggregated traffic from all trains with sufficient throughput and capacity to serve the needs of the Solution at launch, with smooth scalability as demand for capacity increases over time.

4.2.5 Traffic Separation – Passenger and Administrative
On-board passenger traffic is separated from management and control traffic using VLANs.

4.2.6 Condition Monitoring and Alerting

4.2.6.1 Proactive Condition Monitoring
The OSS shall provide real-time monitoring of the state, condition, and health of all core OBN components including but not limited to train-born T2G links and individual modems, ICL and Wi-Fi radios, and Ethernet routers and/or switches. The OSS shall provide email- or SMS-based alerts if any monitored component experiences an operational issue or fault – identifying the train consist GPS location and train service number, rail car ID, OBN ID, and ID of component as necessary. CCJPA shall be able to configure when and which alerts are to be triggered and to whom they are sent by providing Contractor...
with a 'whitelist' and groupings of users by role/function for Contractor to manage and implement (see section 4.2.6.2 Issue Detection & Real-Time Alerts).

The performance of the T2G link will have a direct impact on the quality of Wi-Fi service delivered to passengers, and CCJPA’s ability to leverage the connectivity for operational applications including but not limited to OBIS. The OSS shall provide detailed live and historical information about the active and non-active cellular links including carrier name, availability, network mode (e.g. LTE, HSPA, CDMA, or GPRS), signal strength, modulation rate, current data throughput, latency, jitter, packet loss, and bandwidth utilized over time in both downlink and uplink. It shall be possible to visualize the cellular network performance information by individual mobile operator (e.g., Verizon, AT&T, or T-Mobile) on a map by train service route, with color-coding for CCJPA-selectable values including network availability, mode, signal strength in dBm, and downlink and uplink throughput in Mbps, with CCJPA-selectable levels of sample rate granularity.

Similarly the performance of the train backbone will impact on the quality of Wi-Fi and operational services. The OSS shall provide detailed live and historical information about the ICLs including radio signal strength, modulation rate, channel, current data throughput, latency, jitter, packet loss, and bandwidth utilized over time in both downlink and uplink.

The OSS shall provide a summary of this information on a web page with drill down capabilities to view the individual details in a graphical representation of each train set and cars within a selected train set. The representation of the train will display, at minimum:

- Train service number;
- Total number of cars in the consist including power cars, and their respective car numbers;
- ICL unit (wired or wireless) at the end of each car, colored to show status e.g. actively connected, not connected;
- Physical location of all monitored components.

The OSS shall show a single web page graphical representation of each component in the network using red/yellow/green to indicate the working status of each OBN component, and shall have drill-down capabilities for each component to determine why its status is not green. The drill-down shall provide component detail on-screen including but not limited to:

In addition, The system bandwidth overhead to perform these functions shall be documented by Contractor.
4.2.6.2 Issue Detection and Real Time Alerts

The OSS shall have the ability to set automated alerts that issue 'red flag' notifications in the dashboard and via email and/or SMS when potential issues are detected. Alerts shall be configured to issue notifications based on parameters including but not limited to:

- GPS location;
- Geo-fencing of a specific area;
- Component online/offline status including mobile router, cellular modem, ICL, DTL, or Wi-Fi AP;
- Cellular connection status;
- Number of users.

Contractor shall be able to configure the rules and minimum/maximum thresholds to trigger alerts, and the recipients of alert notifications. Issues detected via this process shall be logged by Contractor's Operations and Maintenance (O&M) team and automatically forwarded to the CCJPA Wi-Fi Services team, who may choose to escalate to Contractor's Tier 2 support if unresolved. Contractor shall detail the issue detection and alert functionality of its Solution, highlighting competitive advantages, and process of interaction with the CCJPA and Contractor service desk components.

4.2.6.3 Supervision and Reporting Solution

The overall supervision and reporting architecture supports a powerful solution that combines all the features of a carrier-grade supervision and reporting solution:

- The [supervision system] oversees the three main functions of a carrier-grade solution:
  - [supervision module]
  - [reporting module]
- The [reporting environment] is responsible for providing a highly flexible easy-to-use reporting environment.

[supervision tool] is the base tool of the supervision team in charge of 24x7 train supervision. It provides [supervision features].

The Reporting and Business Analytics solution is the base tool of the Customer (or the Customer facing team) [reporting tool]. They can easily modify the views. The technical architecture is depicted in the simplified view in Figure 5.
Figure 5: Data flows in the database may be local or in the cloud. For example, at present, the long term database

On board of the train, the RTL (Real-Time Logging) client collects a comprehensive set of monitoring data from all the active devices, which allows real-time graphs of connected devices, and their location. Below are a few typical views.
4.2.7 System Reporting

4.2.7.1 General Requirements

Generating detailed reports is a key function of the OSS. The OSS shall be capable of creating and exporting thorough reports on all aspects of Solution usage and performance over specified time frames including day, week, month and user-defined period. Reports shall deliver individual and aggregated results, statistics and trends for metrics over time by criteria including but not limited to region, route, service number, individual car number, and OBN component ID. Reports shall include but not be limited to Solution operational hours; component uptime and availability; individual and/or aggregate T2G link and Internet gateway traffic levels by various parameters; prediction of future metrics based on trends; and all other monitored metrics outlined in section 4.2.6.1 Proactive Condition Monitoring. It should be possible to compare results by current and prior periods to identify performance gains or losses over time.
CCJPA is reliant on the availability and quality of commercial cellular data networks. These networks may change over time as base station sites are added, adjusted or removed, or network contention fluctuates. As a result, CCJPA needs to be able to generate reports on a regular basis to assess individual or aggregated network capacity and availability. The OSS shall be able to generate cellular network reports by route which include key metrics such as signal strength and downlink and uplink throughput (in Mbps in half-mile (distance) and/or one-minute (time) increments, and cellular modern network mode and availability. Contractor shall detail what additional intelligence the proposed Solution provides in terms of cellular network discovery and analysis.

The OSS shall be capable of providing report summaries of all generated data graphically on screen in the Solution’s dashboard environment, or exported in formats including but not limited to PDF, CSV and Excel. The OSS shall address CCJPA’s need for deep analytics of all data gathered by the system, to help CCJPA and Contractor identify areas requiring improvement and otherwise optimize the Solution.

The OSS element shall enable CCJPA to create all reports and automate delivery of these through the self-service web portal; it shall not be necessary for CCJPA to request reports to be manually generated by Contractor. All raw data collected by the OSS shall be provided in the form of a database backup or export, accessible via the self-service portal. Alternatively CCJPA may run its own queries to obtain the all data generated by the OSS pertinent to the entire Solution’s operations via the OSS API. The OSS capacity shall allow for the retention and storage of at least eighteen (18) months of data.

4.2.7.2 Passenger Wi-Fi Reporting

In order that CCJPA may understand the uptake of Wi-Fi service by its ridership, and thus measure return on investment, the OSS shall provide real-time collection and reporting of Wi-Fi usage statistics that will include but not be limited to the ability to view the total number of users (both VPN and non-VPN); total amount of data sent and/or received; and total session duration, all within a selected time frame (e.g. years, months, weeks, days, hours, or live view) and/or geographical range for a service, train, or individual car. The same data shall be available for an individual user identified by MAC address, while also identifying to which AP in which car the user was connected. All reported metrics shall be displayed in the dashboard environment, with same user interface as other components of the OSS, and be available to external query via the OSS API. Contractor shall provide in its response screenshots of the Solution displaying the required information, with accompanying narrative and step-by-step process for displaying each. In addition the OSS shall have the ability to:

- Record and report the number of times a user agrees to the Terms and Conditions of Service displayed in the captive portal by clicking an ‘I Agree’ button, associating this action with the user's device MAC address;
- Record and report the number of end-user devices connected to each Wi-Fi AP on a train set and/or individual car;
- Record and report the type of end-user devices that utilize the Wi-Fi service, including but not limited to make, model, OS version, and browser type;
- Maintain Google Analytics tracking on all portal pages;
- Maintain records in compliance with CALEA (see section 4.2.11 Working with CALEA).

* In some cases only if made available to Contractor by the landing page developer.
All raw data collected as a result of passenger reporting shall be retained and archived in accordance with the requirements set forth in 6.6.4. *Data Repository.*

4.2.7.3 **Example Screens**

is a highly flexible Reporting tool and is adapted by the Nomad project team on a project-by-project basis to meet customer requirements.

The views shown below were taken from a contractors project and were selected from existing views to illustrate capabilities.

Shown below: An individual train may be selected for an examination of that unit's usage and performance.
reports on data captured at the AP and can provide a further level of intelligence on passenger behavior.

- Based on packet inspection, the application types being used by passengers will be reported.
- Summary of devices associated over time to individual APs.
4.2.8 OBN Traffic Management

The Wi-Fi solution will be implemented with a mechanism for content filtering of passenger Wi-Fi traffic and shaping user experience, as specified in section 4.1.14 On-Board Passenger Experience.

4.2.9 OSS Architecture

Contractor shall explain in detail and by diagram the proposed OSS architecture for review by CCJPA for any WD. This shall include communication; network throughput capacity; security; how the required availability will be met; total system capacity; backup and recovery strategy; how the system will be maintained with the latest patches and security updates; and the function and process of API operation.

The proposed virtual hardware must be identified and selected as among the most reliable and fit-for-purpose for supporting this type of application. The overall OSS solution design shall ensure that no single failure of any component within the system will prevent continuation of processing for all other system components nor prevent successful management of those components. Contractor shall detail how this is accomplished.
4.2.10 System Security & Access
A high level of security is mandatory, and includes firewalls, strong password management, user authentication, and user management. All access to the solution systems, including but not limited to, OSS systems, APIs, databases, reporting tools, monitoring tools, and issues management systems must be done through secure connections over standard ports. The practices deployed within systems to ensure robust and secure levels of access controls to the systems are defined within section 3.4.7 Network Cyber Security.

4.2.11 Working with CALEA
The Solution shall not interfere with an Internet Service Provider's obligations to law enforcement agencies under the Communications Assistance for Law Enforcement Act (CALEA). Contractor shall explain if and how CALEA obligations, if any, have been satisfied with other Contractor Solution deployments in the United States.

4.3 API Segment & Functional Description

4.3.1 Open Data Principle
CCJPA plans to use other on-board and off-board systems and/or web services in conjunction with the Solution; as a result it shall be capable of working with and being accessed by CCJPA systems and services, and make available both technical data (i.e., data related to system function, performance, availability and health) and usage data (i.e., data related to passenger or other system use of the data connectivity). All data shall be made available in a raw format that is "as generated" by the system and not subject to post processing or similar actions. When useful/processed data should be made available alongside the raw data but not as a replacement for the raw data. All data of any kind generated by the Solution – including but not limited to OBN, OSS and API performance and availability, and metrics generated by individual Solution components and sub-systems – shall be the exclusive property of CCJPA and/or its partners, as applicable by fleet and/or WD.

It is required that all data generated by the system to be made available both in real time and from a historic data store. Contractor shall describe the methods that can be used by CCJPA to automatically access both real time and historic data either through one or more APIs or similar methodology, and submit samples of API documentation with its response. Responses that do not show clearly demonstrate that Contractor has a full, open API for data access will be considered non-compliant.

Data APIs shall be provided both within a central location (data center or equivalent) and also as close to the location where data is generated. Contractor shall provide documentation showing how this is accomplished.
4.3.2 Data Structure

The data management method used by Contractor shall allow new data sources to be added to the data structure described in section 4.3.1 Open Data Principle both on a fleet or train basis. Addition of new data elements shall not affect how systems use the existing data APIs. Contractor will describe how new data can be added to the data structure and what controls are in place to determine the effect of new data feeds on system performance, available TZG bandwidth, storage, and system security.

Contractor shall describe accurately for each data element how it has been sourced, the nature of measurement units, and any other factor that will affect CCJPA or other systems that may acquire and utilize this data for analysis. Contractor shall provide a detailed table of the currently available metrics that are captured by the Solution including the sample rates and measurement units.

4.3.3 Data Security

Where data is made available through APIs or similar, Contractor will describe the methods provided to allow CCJPA to control what data is made available to different data users via the APIs and how access controls will prevent unauthorized users accessing either real-time or historic data. This shall be part of Contractor’s overall Cyber Security plan (see section 3.4.7 Network Cyber Security).

4.3.4 Data Availability

Fleet data shall be available through API’s that can be queried both on-train and from the back office, availability of data from the

CCJPA requires that historic data be maintained in one or more data structures that is available for both querying and extract for a period of no less than 18 months after being generated. After that time Contractor shall agree options with CCJPA how specific data shall either be discarded or archived. At no time shall data be discarded without the written permission of CCJPA.

4.3.5 Data Publishing

Data shall be published from the Contractors solution utilizing model as depicted below. Data within the train can be generated and published at different rates, for example GPS data may be made published each second and device temperature may only be published every ten minutes. – for example all GPS data from the train fleet and number of clients on each AP – and as such when that data is available
4.3.6 Data Accuracy

The Solution shall automatically and continuously validate that all required data is being generated and is within expected parameters; is available through the API and storage mechanism(s); and has not been corrupted e.g., data missing from the record. The Solution shall provide both a real-time alert available to Contractor and CCJPA where there is a suspected issue with data capture, and also shall ensure that the associated APIs and long term data storage mechanisms have a means of reporting that either data is missing or may be inaccurate.

4.3.7 Data Fields

The following data fields shall be available as a minimum through the APIs:

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Off train</th>
<th>On train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train Details</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
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4.3.8 OBN Control and Management

CCJPA requires that any component within the OBN can be queried, and where necessary certain actions undertaken, through an API control mechanism. The API which will be accessible directly on the train and also from a remote location will allow the following actions to be undertaken:

1. Reboot of device (e.g., modem, mobile router, AP, or Ethernet switch);
2. Reboot of function within device (e.g., radio within AP or functional process);
3. Extract fault logs from within device.

The purpose of this API is to allow the Solution to have a level of management that can be easily undertaken by a suitably skilled third party following a basic fault finding guide to resolve simple issues. Contractor should also provide a web interface on the mobile router that can be presented to a mobile device or to a touchscreen panel already integrated on the train. Any actions undertaken using the API will be recorded so it can be audited later to determine what actions were taken and the outcome of the actions.

4.4 Connectivity to Other Systems

4.4.1 Business and other Operational Systems

CCJPA currently uses and may also seek to integrate other systems on a per car or fleet basis which will require integration with the Solution. It can be assumed that these systems may require functionality including but not limited to:

1. Bi-directional T2G connectivity;
2. IP address allocation or have IP addresses assigned automatically by the Solution;
3. Real-time GPS data;
4. Monitoring to extract data from a device API and making this data available both on-train for other systems or off-train for analysis. This may need to be aligned with other data sources (e.g., GPS data, or real time clock) that already exist within the Solution;
5. Monitoring of hardware to trigger an alert if the device is off-line or functioning out of band;
6. Secure communication through the train line between system components.

4.4.2 OBIS Integration

Contractor may be required to install the Solution on rail cars that are already fitted with, or may be about to be fitted with, an On-Board Information System (OBIS) which is described as an automated video and audio on-train passenger information solution that is designed to be journey specific and possibly updated in near real-time, but may take various forms depending on the particular car type and designed functionality. The OBIS solution will be sourced from one or more suppliers and is designed to provide digital signage and automated announcements to passengers based on real time train location and centrally-generated messaging. OBIS requires integration with three primary functions of a Next Generation Wi-Fi solution.
1. **T2G connectivity.** OBIS will both pull and push data periodically to an off-train server to obtain updated route and consist details and also any information related to the live train schedule;

2. **GPS data.** OBIS will periodically query the train Wi-Fi system to obtain real-time GPS location data that can be used to trigger appropriate messaging;

3. **Connectivity between cars.** It should be assumed that the OBIS platform will incorporate one or more Ethernet switches to provide connectivity between its own sub-system components. These Ethernet switches will need to share the IP connectivity that is created between adjacent cars.

Where integration with OBIS is required then Contractor will be provided with an Interface Control Document (ICD) that describes how each of the above interfaces will function and how the Solution is required provide the correct integration with OBIS. Contractor should expect to provide the following as a minimum:

1. A specific logical interface on the mobile router that will be used by OBIS to pull or push data to and from the train. Data on that interface will be in a segregated VLAN and the router will ensure that data to and from this interface is transmitted uninhibited to and from the OBIS back office. It may be necessary to provide a specific, dedicated connection (e.g., a VPN) between the Solution’s back office and the OBIS back office for all data transfer;

2. Contractor will undertake a security scan and penetration test on the Solution to provide assurance to the OBIS supplier (as responsible party for the overall OBIS security) that the Solution has sufficient InfoSec security protocols in place to assure secure OBIS operation. The InfoSec requirements will be defined within the ICD document referred above;

3. Contractor may be required to provide equipment (under a WD provision) to augment one or more OBIS test benches which are used to validate OBIS firmware and configuration changes. These test benches will be located both in CCJPA’s facility and in the OBIS supplier’s. The test benches may be fitted with a device acting as simulator of Contractor’s solution as long as it can be demonstrated as providing identical performance and function as the on-board solution. The OBIS benches will have to be maintained to an identical release firmware and hardware as the on-board solution. Any changes planned to the train solution will also have to be validated first on the OBIS bench environments in accordance with a mutually agreed change control process;

4. Provision of GPS data to the OBIS solution (or other on-board system requiring a GPS feed e.g., Passenger Experience Probe) shall be in accordance with the ICD and can be assumed to be a SNMP query undertaken at one-second intervals;

5. The Solution will be expected to provide car-to-car connectivity for OBIS by supporting multiple VLANS without disruption and being able to transfer several concurrent multicast data streams and other TCP data. CCJPA will advise if and how the OBIS data should be prioritized over other network traffic.

The Solution will not be required to provide any monitoring of the OBIS solution components but should be able to provide (and present for external query by API) metrics related to the data being passed for OBIS, in both directions, between train and back office.
4.5 OBN General Hardware & Mechanical Requirements

4.5.1 Cables & Connectors

All cables and wiring in the Solution shall comply with Amtrak SPEC 323-C High Performance Wire and Cable §. All connectors shall:

- Have positive lock mechanism;
- Be commonly available;
- Use keying and color-coding to prevent incorrect connections during maintenance;
- Be waterproof if mounted in the ceiling or in the vestibules;
- Have non-threaded connections, where possible;
- Have a cable bonded to connector body to prevent stressing electrical connections if cable is pulled or subject to abuse during vehicle or system maintenance.

All connectors of the same type and size shall be keyed to avoid insertion into the incorrect location. Connectors shall be identified in accordance with the schematic designation. All connector types shall be submitted to CCJPA for approval during design review. All on-board equipment enclosures shall be connected through robust, quick disconnect, multi-pin connectors with removable crimp contacts. The connectors shall be located in the front of the equipment or other easily accessible locations for quick connection and disconnection. No cables shall be run in passenger access areas without being enclosed in conduit. Any cables designed to run underneath the car body or in areas where in normal train maintenance operations may be under foot shall be run inside metal conduit. Contractor shall ensure that, where cables are routed through a conduit, small signal cables are not routed inside the same conduit as cables carrying power feeds to minimize the effects of interference.

Contractor shall propose a method of cable marking and identification that provides detail of cable function and also makes it clear where each cable is intended to be connected so that during normal maintenance operations it is possible to check all cable connections without reference to a circuit diagram.

All cables, cable markers and conduit that are on the interior of the car body shall meet applicable federal smoke, flame and toxicity requirements.

4.5.2 Power

Contractor shall assume that 72 VDC will be available on each rail car, and that it will be possible to run power cabling from the rail car power supply to OBN components as required. The OBN solution shall be able to utilize the available power source; have sufficient power management for protection against fluctuations in voltage and current without damage; and shut down after a predetermined period to avoid train battery drain. Contractor shall provide CCJPA with the continuous and peak power that the on-train components are expected to draw under normal operating conditions. Selected equipment designed to run on DC power must have the ability to detect the loss of Head End Power (HEP) and shed their load from the DC bus. The equipment to be load shed in the event of loss of HEP shall be agreed between Contractor and CCJPA during the design phase.

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§ http://bit.ly/2N0jJ3n
In event of a loss of train power and subsequent restoration, all OBN components including ICLs, mobile router, and passenger Wi-Fi APs, shall automatically reboot without manual intervention. Components shall have a reboot time of fewer than 120 seconds to recover to normal operation including re-establishment of T2G communication. No re-configuration or manual intervention shall be required on completion of a reboot cycle. It should be noted that some sub-system components which may be using the Wi-Fi infrastructure will not power cycle during temporary loss of power and as such the Solution shall be capable of fully re-configuring without affecting these systems.

CCJPA expects that due to the age of some rail cars the 72V DC power available within the train fleets will not meet typical railway standards (e.g., voltage surges, spikes and dips). Contractor is responsible within the scope of each WD where equipment is being introduced into a car type to properly test the power environment and ensure that new equipment is designed to function reliably within this environment. Contractor will describe the process that will be followed to validate the power environment and how this data could be used within the system design.

Contractor shall provide details of power consumption per OBN component detailing both maximum rated current and steady state, and describe the electrical isolation that is provided between each item of equipment and the rail car electrical power circuits and the rail car chassis.

Contractor shall describe their approach to system earthing (including cable screens) through the WD response and delivery to ensure conformance with mandatory standards, reliable system operation and electrical safety for passengers, train crew, and maintenance staff.

4.5.3 Manual Power Cycling

Should the OBN components require rebooting for whatever reason, it shall be possible via a single ‘hot button’ process whereby, when instructed to do so, CCJPA personnel (e.g., the train conductor) can press a single button to commence a power cycling procedure whereby all Solution components restart in a pre-defined order. At the end of the reboot process the Solution shall resume normal operation. The back office shall log when such manual power cycling occurs and automatically create a trouble ticket for support escalation.

4.5.4 Cooling

CCJPA prefers that all powered hardware shall be cooled by natural convection, and shall not require a separate fan or other device to provide forced air cooling. All components shall be mounted in a way that facilitates natural airflow and prevents overheating. During the detailed design phase for each WD, Contractor shall specify the maximum ambient temperature that can be tolerated by the Solution’s OBN components, and ensure that the equipment shall meet the temperature tolerances identified when installed in the space provided.

Where forced air cooling is recommended by Contractor then details shall be provided to describe:

- Calculated and actual MTBF for the cooling system;
- Additional maintenance requirements for the cooling system (e.g., replacement of filters);
- Visibility of faults associated with the cooling system (e.g., if a fan fails or airflow affected, how is this indicated on and off train). CCJPA seeks a visible indication of system operation status.
4.5.5 EMI and RF Interference

All equipment provided by Contractor shall meet relevant U.S. national and railway industry requirements related to electromagnetic interference (EMI). Contractor will provide evidence of compliance for all OBN and sub-system components including any certifications and third party test reports.

None of the proposed equipment shall generate harmful interference in the VHF spectrum currently allocated to the U.S. and Canadian railroads for safety applications, including but not limited to Positive Train Control (PTC). All equipment shall conform to all current applicable FCC regulations and be certified to meet current applicable FCC requirements. The equipment shall comply with, and not interfere with, all available FRA mandated emergency or safety systems. Contractor shall make available to CCJPA all relevant test reports for equipment for review by CCJPA and shall submit them as part of the formal approval process for each installation.

4.5.6 OBN Standards Compliance

All new OBN components required to support the Solution shall comply with standards including but not limited to UL (UL 94-V0 for non-metallic items, state compliance to UL 50 or equivalent standard), FCC Part 15, EN 50155, IEC 60571, AREMA 11.5.1 C&S Manual for Class I (Vehicle Interior Platform Mounted) equipment (Temperature, Humidity, Mechanical Shock, Abrasive Environment, and EMI), and other relevant rolling stock on-board electronics standards and industry guidelines. Contractor shall meet all requirements stated in Amtrak Specifications for Components to be Installed on High Speed Train Set ⁶ and Amtrak SPEC 429-B Environmental and Operating Conditions ⁷. All proposed equipment is required to be approved by CCJPA prior to installation.

CCJPA retains the right to request via specific WOs conformance to additional standards which may be applicable to specific fleets or applications that are not listed within this CSOW. Awareness and compliance with emerging industry or national standards that are introduced through the contract period are the responsibility of Contractor. Where these may impact existing or new installations Contractor is responsible to notify CCJPA of these areas and to advise impacts of any new requirements.

Conformance with mandatory and industry standards should be achieved within each OBN component and not through external materials added and incorporated during the installation phase (e.g., external RF chokes, or external voltage suppression).

4.5.7 Ruggedized Equipment

All externally and internally mounted equipment from Contractor and any third party shall be ruggedized and withstand environmental and operating conditions, including extremes of temperature, moisture/humidity, and shock and vibration that can be expected within a railway environment. The ability to withstand the railway environment will be a design feature of the individual components and not any secondary protection provided as part of the installation process.

⁶ http://bit.ly/2NmsDFa
The whole solution and its individual components shall be UL approved. All OBN components shall be
immune to any particulates of diesel smoke emissions and any cleaning agents; designed to prevent
water intrusion; and shall pass federal smoke, flame, and toxicity requirements.

Contractor shall clearly state the federal, state, and/or industry standards with which the Solution
components comply and any specific pass criteria that have been applied. Contractor shall provide a
conformance plan that details how new or modified system components are tested to assure compliance.

4.5.8 Modularity
The Solution shall be modular and have the ability to be maintained via a simple swap-and-replace
program for both upgrades and repairs. Contractor shall provide diagrams showing how the system is
divided into modules clearly showing the Line Replaceable Units and where items can be exchanged in
the field versus in Contractor’s repair facility. Contractor shall maintain and update all equipment without
disturbing other non-Solution equipment.

4.5.9 Remote Updates & Configuration
CCJPA wishes to minimize the requirement for truck rolls (e.g., on-site attendance by Contractor or
CCJPA or partner field engineers) to perform software updates and/or device configuration changes. The
Solution utilizes a centralized controller architecture for all configurable components to manage software
and configuration updates. In addition automated validation of the system component configuration will be
undertaken routinely and the details provided through an API, see Section 4.3 API Segment & Functional
Description.

Where it is not possible to reach a device remotely then it will be necessary to dispatch a field engineer to
undertake site investigation and repair.

4.5.10 Power Outages
All OBN hardware and software components shall survive unexpected power outages or spikes without
damage. All components shall have a reboot time of less than 120 seconds to recover to normal
operation. No manual re-configuration shall be required on completion of a reboot cycle. All components
shall resume normal operation following supply power interruptions after a self-test is completed. As
stated previously Contractor must consider that all connected devices on the network may not be subject
to power cycling at the same time or under the same voltage conditions.

4.5.11 Workmanship and CCJPA Approval
All processes and workmanship shall comply with Amtrak SPEC 854-1 Vehicle Design-Build
Components* and Amtrak SPEC 328-1 Materials and Workmanship* respectively. All custom mounting for
on-board equipment shall be approved by CCJPA and comply with 49CFR Part 238. Contractor will
describe how design information will be presented to demonstrate conformance with these requirements.

4.5.12 Coordination with CCJPA’s or other Stakeholders Mechanical Department

Contractor shall be required to work with the engineering team(s) of CCJPA, other stakeholders’ applicable engineering departments, and CCJPA partners or their representatives during installation phases to ensure that the proposed Solution meets all relevant specifications (as agreed at the commencement of a WD rollout) including, but not limited to, those for vibration, heat, electrical, and radio interference; and others as set forth within this CSOW. Contractor will describe the typical process that will be followed to ensure conformance with the requirements of these teams.

4.5.13 Equipment not to Impact Maintenance and Other Train Systems

Contractor’s Solution shall not require the removal or alteration of any equipment on trains not related to the proposed Solution. All components shall conform to the space provided and will not in any way interfere with or prevent maintenance of other existing train systems. In addition, new roof-mounted antennas shall be positioned and installed in such a way so that they shall not cause RF interference with – and be at sufficient distance from – existing roof-mounted antennas.

Where other CCJPA sub-systems are to be connected to the Solution infrastructure and could be affected by outages or maintenance to the Wi-Fi system, Contractor shall have a robust process in place to allow communication to the parties responsible for downstream systems so that all relevant parties are aware of issues.

4.5.14 Additional OBN & General Requirements

In addition to meeting the requirements stated in this section, Contractor shall be required to state compliance with the additional requirements contained this CSOW, and in future WD SOWs.

If the proposed Solution includes parts visible to the passengers (e.g., in-car Wi-Fi antennas), the visible parts should match the surroundings with regards to interior design and shall be agreed in advance with CCJPA, and any other stakeholders, for aesthetics and also safety to passengers. CCJPA prefers a Solution where no parts are visible to the passengers.
5 Project Delivery Per Work Directive

This section describes the high-level model for full-cycle implementation for WDs, using Contractor's employees and, if applicable, subcontractors.

5.1 Work Directive Process

WDs will be issued by CCJPA or other rail partner(s) as required for selected rail cars in variable quantities e.g., individually, in sets, or entire fleets. Each WD shall include the work scope and number of cars to be included. Large jobs which require extensive work shall likely be accomplished via a single WD. Contractor shall submit a proposal for each WD and on approval by CCJPA and/or its partners, an NTP under the MSA will be issued.

The scope of work per WD is considered to include a full life cycle implementation from initial inception, technical system design, installation and ongoing system operation and maintenance. Each WD will define requirements, specifications and detailed design and, where needed, customize them on the basis route and other factors. Any change in the requirements or specifications will be communicated to Contractor as part of the WD SOW. All changes and additions proposed as part of Contractor's WD response will be subject to CCJPA's or its partner(s) approval.

For each WD, Contractor shall propose a complete and detailed project plan as outlined in this section and submit it to CCJPA for approval before commencing the work. If applicable, Contractor shall identify key delivery partners to facilitate each stage of the SOW. As part of the response to each WD issued SOW, Contractor shall indicate the subcontractors (if any) who be involved in executing the WD. Subcontractors will have a recognized track record within their particular skill set to ensure that implementation is performed to the satisfaction of CCJPA. Any changes in subcontractors must be approved by CCJPA before WD commencement, but shall not be unreasonably withheld.

5.2 Project Team

The project will be supported by a multi-disciplinary team with leadership provided by senior CCJPA personnel at MSA level; other stakeholders and partners as defined and coordinated by CCJPA shall participate as needed, e.g., personnel of Caltrans, other Joint Powers Authorities, rail operators, and other partners relevant to a particular WD. All shall work together to provide monitoring and evaluation of performance, with accountability for the achievement of the targeted project outcome. All required WD deliverables shall be reviewed with CCJPA and the final versions shall be approved by CCJPA. Contractor shall use (where available) CCJPA-provided templates for creating the project deliverables.

Contractor shall serve as the main point of contact for CCJPA program management and Wi-Fi Services personnel, and is expected to manage the work of any and all subcontractors and coordinate with CCJPA personnel when necessary to ensure timely completion of the WD. Contractor shall identify a project team for each individual WD, depending on the specific requirements of a given WD, location, resource availability, expertise, and cost.

It is envisaged that the project team structure will encompass the following key roles and responsibilities, with company affiliation indicated in brackets:
5.2.1 Project Executive/Director (Contractor)

The Contractor Project Director will be responsible for the implementation and delivery of all the WDs that shall arise from the MSA. The Contractor Project Director shall be the main point of contact to CCJPA for all WDs, and shall be responsible for building and supporting the project teams as they are deployed on any specific WD.

The Contractor Project Director will be supported by one or more Contractor Project Managers, who shall manage the detail of the contracts in place with the various subcontractors. The individual WD Project Manager (described below) will take responsibility for the technical delivery of any individual project, and ensure that financial controls are maintained.

5.2.2 Work Directive Project Manager (Contractor)

The Contractor Project Manager will report to the Contractor Project Director and also communicate directly with CCJPA’s project team, generating and maintaining a live project plan, and providing regular updates on progress and any issues that shall arise. The Contractor Project Manager will be supported by the Contractor Project Director and his or her team to ensure commercial management of all subcontractors can be coordinated in parallel with the technical delivery of the project.

Contractor will define minimum professional qualification, certification and experience of the Project Manager that shall be used in the execution of any WD.

As CCJPA considers this role to be critical to the success of any WD, CCJPA requires that they be provided with the details of the selected WD Project Manager for review and acceptance based on experience, qualification and, if necessary, interview. This will be undertaken during the specific WD negotiation phase.

5.2.3 System Design (Contractor)

Contractor shall nominate a single technical authority for the Solution to be implemented. This person shall take overall responsibility for ensuring that the solution is designed to meet all functional requirements, and to define the specific installation constraints to ensure optimal operation. All system requirements defined for the WD are communicated to the rest of Contractor’s team by the technical authority to ensure that all OBN installation and OSS configuration is undertaken as required for the specific WD. This activity will be led by a suitably qualified engineer within Contractor’s team, who shall report to the WD Contractor Project Manager and also directly to CCJPA as required.

5.2.4 Materials Staging (Contractor)

Contractor shall be responsible for the configuration and kitting of their respective materials, and for ensuring that these are delivered to the designated installation site when required and in quantities to match the production schedule. The Materials Staging responsibilities include:

1. Choice of main OBN component suppliers;
2. Supplier quotes including deliveries;
3. Supplier management;
4. Placing of purchase orders;
5. Managing supplier schedules;
6. Payment of suppliers;
7. Supply work instructions;
8. Supply configuration settings and train staff;
9. Supply all specialist test equipment;
10. Choice of fixtures supplier, subject to Contractor and CCJPA sign off;
11. Management of the process to Contractor’s requirements and to International Standardization Organization (ISO) 9001;
12. Goods receive process;
13. Safe and secure storage of goods at rail yards and other sites as required;
14. Configuration of on-board equipment;
15. Recordation of serial numbers, MAC addresses and other data into Contractor’s asset register;
16. Preparation of rail car OBN kits (‘kitting’);
17. Provision of documentation (e.g. bill of materials, packing list);
18. Shipment to local depot and recordation of delivery;
19. Provision of shipper tracking numbers to CCJPA staff, and maintenance of shipping log online;
20. Identification of materials that failed to arrive, either on time or missing from a shipment;
21. Remediation of the above issues;
22. Management of the return materials authorization (RMA) process for warranty and faulty goods.

5.2.5 Rail Car Installation (CCJPA, Contractor)
Contractor will either:

1. Carry out the installation on a given car, or
2. If CCJPA’s train maintainer carries out the installation itself, Contractor will provide on-site supervisory support during the installation process. CCJPA’s train maintainer will always be given first right of refusal to perform car installation services.

5.2.6 Commissioning (Contractor)
Commissioning refers to the post-installation configuration and testing of a rail car OBN and interaction with the OSS before handing over to CCJPA for validation and acceptance. Contractor may undertake the commissioning itself or utilize a subcontractor to undertake independent commissioning of the operation of each car. Contractor shall develop a commissioning process for CCJPA review and approval prior to commencement of installations. Contractor shall undertake sample audits of installations to ensure that on wide deployments consistent quality is being maintained. Sample audits shall be conducted on a percentage of installed cars that shall be agreed a WD basis between Contractor and CCJPA.

5.2.7 Validation and Acceptance (CCJPA)
After Contractor has completed commissioning on any given rail car, CCJPA personnel shall conduct a Solution validation process to test and verify that the Solution is operating in the manner expected. Separate validation processes will be developed by CCJPA for each car type, e.g., brain cars containing centralized Solution components including mobile routers and T2G cellular connectivity; intermediate cars containing passenger-facing APs and ICLS; and DTL for multiple car and/or whole train LAN connectivity. Only on successful completion of the validation process shall a car be considered accepted for service by CCJPA.
5.3 Stage 1 – Planning and Project Management

5.3.1 Kick-Off Meeting
Following CCJPA’s acceptance of Contractor’s proposal and project team for a specific WD, the project will be initiated with a start-up meeting attended by Contractor, all relevant subcontractors, and CCJPA (and its partners where applicable). The prime purpose of this meeting is to review the full project scope, and agree on the role of each individual and organization. The communication structure will be defined and agreed between Contractor and CCJPA. It will include how often project meetings are required, and the attendees required to participate at each review meeting. Agenda items for the kick-off meeting shall include at a minimum:

- Purpose of the meeting;
- Project objectives;
- Assumptions and constraints;
- Project scope including high-level business requirements;
- Project schedule and key milestones;
- Project organization and key personnel;
- Project risks and issues.

Contractor shall ensure that the project team structure will work independently of company boundaries. Contractor shall promote and aim to maintain an open project structure in which CCJPA is encouraged to speak directly across the project delivery team for detailed information on any aspect of the project. While this shall not replace the formal project reporting from the WD Contractor Project Manager and Contractor Project Director, it is often the clearest and most efficient way to communicate details as required.

5.3.2 Project Management & Implementation Plan
For each WD a comprehensive Project Management Plan (‘PMP’) shall be developed by the Contractor Project Manager, supported by the Contractor Project Director, and agreed with CCJPA and all of Contractor’s relevant subcontractors, partners and suppliers. The PMP will describe the work to be performed, how the project shall be operated, and procedures that direct activities to ensure that key tasks are performed in a systematic and visible manner. As a minimum, this plan shall address the following key aspects of project control:

1. Definitions and specifications;
2. Scope management;
3. Staffing management and role definitions;
4. Change control and associated pricing;
5. Work breakdown structure;
6. Cost control and tracking against cost pro forma sheet;
7. Document and data control;
8. Design management;
9. Interface management and integration;
10. Configuration management;
11. Supplier management and qualification;
12. Procurement and identification of OBN components with long lead times;
13. Materials management and logistics;
14. Approvals;
15. Safety management;
16. Environmental management;
17. Installation management;
18. API testing and validation;
19. Testing, commissioning and acceptance;
20. Project plan with dependencies, required resources, and review milestones;
21. Progress reporting;
22. Project and stage review processes;
23. Communication management;
24. KPIs and performance measurement;
25. SLA management;
26. Training and Documentation;
27. Documentation QA and approval;
28. Operation, maintenance, and support.

The PMP shall provide particular detail regarding the following key activities:

5.3.2.1 Project Scope Management
The WD project scope is defined with the PMP by the Scope Statement, Work Breakdown Structure (WBS), and WBK Dictionary. The Contractor Project Manager, Director, and stakeholders will establish and approve documentation for measuring project scope which includes deliverable quality checklists and work performance measurements.

Proposed scope changes may be initiated by the Contractor Project Manager, stakeholders, or any member of the project team. All change requests will be submitted to the Contractor Project Manager who will then evaluate the requested scope change. Upon acceptance of the scope change request the Contractor Project Manager will submit the scope change request to the Change Advisory Board (CAB, established at project commencement) and Contractor Project Director for acceptance. The composition of the CAB shall be approved by CCJPA, and include CCJPA team members. Upon approval of scope changes by the CAB and Contractor Project Director, the Contractor Project Manager will update all project documents and communicate the scope change to all stakeholders. Based on feedback and input from the Contractor Project Manager and stakeholders, the Contractor Project Director is responsible for the acceptance of the final project deliverables and project scope.

5.3.2.2 Schedule Management
Project planning and management shall be undertaken using an on-line project management and collaboration tool that shall allow CCJPA real time access to the project schedule, allocated sub-tasks and the status of all items. The schedule and all sub-tasks shall be maintained in real time so that the status shown is the most current for the project.

Activity definition will identify the specific work packages that must be performed to complete each deliverable. Activity sequencing will be used to determine the order of work packages and assign relationships between project activities. Activity duration estimating will be used to calculate the number of work periods required to complete work packages. Resource estimating will be used to assign resources to work packages in order to complete schedule development.
Once a preliminary schedule has been developed, it will be reviewed by the project team and any resources tentatively assigned to project tasks. The project team and resources must agree to the proposed work package assignments, durations, and schedule. Once this is achieved the Contractor Project Director will review and approve the schedule and it will then be base-lined. The following will be designated as milestones for all project schedules:

1. Completion of scope statement and WBS/WBS Dictionary;
2. Base-lined project schedule;
3. Project kick-off;
4. Approval of roles and responsibilities;
5. Requirements definition approval;
6. Completion of data mapping/inventory;
7. Project implementation;
8. Detailed Design Package;
9. WD First Train Installation;
10. WD Last Installation;
11. Acceptance of final deliverables.

Roles and responsibilities for schedule development are as follows:

- The Contractor Project Manager will be responsible for facilitating work package definition, sequencing, and estimating duration and resources with the project team. The Contractor Project Manager will also create the project schedule using MS Project and validate the schedule with the project team, stakeholders, and the Contractor Project Director. The Contractor Project Manager will obtain schedule approval from the Contractor Project Director and base line the schedule.

- The project team is responsible for participating in work package definition, sequencing, duration, and resource estimating. The project team will also review and validate the proposed schedule and perform assigned activities once the schedule is approved.

The Contractor Project Director and CCJPA Project Manager will participate in reviews of the proposed schedule and approve the final schedule before it is base-lined. The project stakeholders will participate in reviews of the proposed schedule and assist in its validation.

5.3.2.3 Risk Management

The approach for managing risks includes a methodical process by which the project team identifies, scores, and ranks the various risks. Every effort will be made to proactively identify risks in order to implement a mitigation strategy from the project’s onset. The most likely and highest impact risks are added to the project schedule to ensure that the assigned risk managers take the necessary steps to implement the mitigation response at the appropriate time during the schedule. Risk managers will provide status updates on their assigned risks in the scheduled project team meetings, but only when the meetings include their risks planned timeframe.

Upon the completion of the project, during the closing process, the Contractor Project Manager will analyze each risk as well as the risk management process. Based on this analysis, the Contractor Project Manager will identify any improvements that can be made to the risk management process for future projects. These improvements will be captured as part of the lessons learned knowledge base.
5.3.2.4 Change Control & Management

Once project definitions have been clearly established and approved by CCJPA, any further potential changes will be identified, assessed, priced (where applicable) and approved by CCJPA before implementation. Where a specific WD relates to non-CCJPA rail cars, change control shall be facilitated via CCJPA in conjunction with, and with the involvement of, its partners. Contractor shall manage change on all roll-outs in accordance with CCJPA’s own management process, referred to as Change Control. This process will allow any stakeholder in the project to propose changes. All changes shall require the approval of Contractor and CCJPA.

Change control submission and execution process shall be established by CCJPA and Contractor in the MSA CSOW, based on the Solution’s commercial approach. For example, a Change Control Request Form may be filled out for all future pre-planned enhancements and changes to the Solution components (hardware, software, or support systems). Some examples of changes include, but shall not be limited to:

- Software configuration;
- Software releases (upgrades/patches);
- Firmware upgrades;
- New hardware introduction;
- Existing hardware modification.

A Change Control Log shall be created and managed by the Contractor Project Manager to keep track of all Change Control Requests submitted and their acceptance and execution. No changes shall be made to the production system without using this process. Emergency fixes (unplanned) that resolve a direct and immediate impact on users will be considered on a case-by-case basis. CCJPA’s approval shall be required for all emergency fixes where sufficient time and resources are available to request such approval.

The Contractor Project Manager shall manage the Change Control process. All Change Control Requests shall be sent directly to the Project Manager, who shall add them to the Change Control Log and usher them through the approval process. A maintenance window will be established for the preferred window for pre-planned activities. This window may change from task-to-task depending on the availability of cars with any required protection services. Using this timeframe will minimize any potential impact to rolling stock and allow the greatest amount of available support. Any pre-planned changes implemented within the maintenance window must also allow time for those changes to be regression tested, and if need be, backed out.

All Changes will be tracked for submittal, review, approval, and implementation using the CCJPA provided Change Control Log. After implementation, Contractor shall inform the requestor of the implemented change(s) and provide test results and a report, if appropriate and previously agreed. This report shall be provided to the CCJPA Project Manager within 24 hours of the implemented change(s).

5.3.2.5 Quality Management

All members of the project team will play a role in quality management. It is imperative that the team ensures that work is completed at an adequate level of quality from individual work packages to the final project deliverable. The following are the quality roles and responsibilities for WDs:
• The Contractor Project Director is responsible for approving all quality standards for the work within the WD. The Project Director will review all project tasks and deliverables to ensure compliance with established and approved quality standards. Additionally, the Contractor Project Director will sign off on the final acceptance of the project deliverable;
• The Contractor Project Manager is responsible for quality management throughout the duration of the project. The Project Manager is responsible for implementing the Quality Management Plan and ensuring all tasks, processes, and documentation are compliant with the plan. The Project Manager will work with the project's quality specialist to establish acceptable quality standards. The Contractor Project Manager is also responsible for communicating and tracking all quality standards to the project team and stakeholders;
• The Contractor Quality Specialist is responsible for working with the Contractor Project Manager to develop and implement the Quality Management Plan. Quality Specialist will recommend tools and methodologies for tracking quality and standards to establish acceptable quality levels. The Quality Specialist will create and maintain Quality Control and Assurance Logs throughout the project;
• The remaining members of the project team, and additional stakeholders as required, will be responsible for assisting the Contractor Project Manager and Quality Specialist in the establishment of acceptable quality standards. They will also work to ensure that all quality standards are met and communicate any concerns regarding quality to the Contractor Project Manager.

Quality control for the project will utilize tools and methodologies for ensuring that all project deliverables comply with approved quality standards. To meet deliverable requirements and expectations, Contractor shall implement a formal process in which quality standards are measured and accepted. The Contractor Project Manager will ensure all quality standards and quality control activities are met throughout the project. The Quality Specialist will assist the Contractor Project Manager in verifying that all quality standards are met for each deliverable. If any changes are proposed and approved by the Contractor Project Director and CAB, the Contractor Project Manager is responsible for communicating the changes to the CCJPA Project Manager and project team, and updating all project plans and documentation.

5.3.2.6 Document Management

Documents refer to all project records and deliverables. Document management is the process of organizing, storing, protecting, and sharing documents. Contractor's document management will achieve this overall goal through the following objectives:

1. Provide safe storage and backup of all documents in a project library;
2. Provide clarity regarding which version of a deliverable is the latest version;
3. Provide a clear record of approved deliverables over the life of the project;
4. Provide measures to maintain restricted access to confidential documents.

Contractor shall develop a standard naming convention for all project documentation that will be consistently employed for all project documents. Changes to documents shall be tracked to reflect date and type of change and persons responsible. Prior versions shall be archived for reference as needed. Contractor shall employ a change log table in every formal document. All drawings and models of CCJPA cars will be done in an agreed CAD format and provided in that format and PDF to CCJPA.
Contractor shall utilize a secure, online repository for all project documentation accessible via a standard web browser. The repository will contain the official versions of project documentation to include technical design, bill of materials, project plans, risk matrices, installation plans and photographs, test and commissioning reports, change orders, and other project resources. The repository will be backed up regularly so that in the event of system failure the project documentation will be preserved.

Deliverable documents require review and approval of the Contractor Project Manager and Contractor Project Director, where appropriate, prior to submission to the CCJPA Project Manager.

5.3.2.7 Procurement Management

The Contractor Project Manager will provide oversight and management for all procurement activities for each WD. The Project Manager will work with the project team to identify all items to be procured for the successful completion of the project. Contractor shall then review the procurement list prior to submitting it to its purchasing department. Contractor purchasing department will review the procurement items, and begin the vendor selection, purchasing, and contracting process.

The project team will work with Contractor procurement department to define the item types, quantities, services and required delivery dates. Contractor procurement department will then solicit bids from various vendors in order to procure the items within the required time frame and at a fair and reasonable cost under the firm fixed price contract once the vendor is selected. CCJPA reserves the right to review Contractor procurement and to reject the selected source, if deemed unacceptable to CCJPA.

5.3.2.8 Communications Management

The Communications Management Plan sets the communications framework for each WD. It will serve as a guide for communications throughout the life of the work defined within the WD and will be updated as communication requirements change. This plan identifies and defines the roles of project team members as they pertain to communications. It also includes a communications matrix that maps the communication requirements of this project, and communication conduct for meetings and other forms of communication. A project team directory is also included to provide contact information for all stakeholders directly involved in the project.

The Contractor Project Manager will take the lead role in ensuring effective communications on this project. The communications requirements are documented in the Communications matrix below:

<table>
<thead>
<tr>
<th>Communication Type</th>
<th>Description</th>
<th>Frequency</th>
<th>Format</th>
<th>Participants / Distribution</th>
<th>Deliverable</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly Status Report</td>
<td>Email summary of project status</td>
<td>Weekly</td>
<td>Email</td>
<td>Project Director, Team and Stakeholders</td>
<td>Status Report</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Weekly Project Team Meeting</td>
<td>Meeting to review action register and status</td>
<td>Weekly</td>
<td>In Person/ Conference call</td>
<td>Project Team</td>
<td>Minutes, Updated Action Register</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Project Monthly Review (PMR)</td>
<td>Present metrics and status to team and Director</td>
<td>Monthly</td>
<td>In Person/ Conference call</td>
<td>Project Director, Team and CCJPA Project Team</td>
<td>Minutes, Status and Metric Presentation</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Project Gate Reviews</td>
<td>Present closeout of project phases and kickoff next phase</td>
<td>As Needed</td>
<td>In Person/ Conference call</td>
<td>Project Director, Team and CCJPA Project Team</td>
<td>Phase completion report and phase kickoff</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Technical Design Review</td>
<td>Review of any technical designs or</td>
<td>As Needed</td>
<td>In Person/ Conference call</td>
<td>Project Team</td>
<td>Technical Design Package</td>
<td>Project Manager</td>
</tr>
<tr>
<td>Communication Type</td>
<td>Description</td>
<td>Frequency</td>
<td>Format</td>
<td>Participants / Distribution</td>
<td>Deliverable</td>
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<tr>
<td>work associated with the project</td>
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<td></td>
</tr>
</tbody>
</table>

**Meetings**
The Contractor Project Manager will distribute a meeting agenda at least two (2) days prior to any scheduled meeting and all participants are expected to review the agenda prior to the meeting. It is imperative that all participants arrive to each meeting on time. Meeting minutes will be distributed no later than 24 hours after each meeting is completed. All meetings shall have the options of attendance in person and using a phone conference bridge with screen-sharing capability.

**Email**
All email pertaining to the project should be professional, free of errors, and provide brief communication. Email should be distributed to the correct project participants in accordance with the communication matrix above based on its content. All attachments should be in MS Word, MS Excel, MS Project, or Adobe PDF format and adhere to established formats. For ease of collaboration Contractor shall have the option of using Google's web-based software suite (i.e., Google Docs, Google Sheets and Google Slides) in addition to email. If the email is to bring an issue forward then it should discuss what the issue is, provide a brief background on the issue, and provide a recommendation to correct the issue. Contractor and CCJPA Project Managers should be included on any email pertaining to the project.

**Informal Communications**
While informal communication is a part of every project and is necessary for successful project completion, any issues, concerns, or updates that arise from informal discussion between team members must be communicated to the Contractor Project Manager so the appropriate action may be taken.

**Training & Documentation**
Contractor shall provide a plan for training CCJPA personnel in the use of the Solution. This training shall be sufficient to ensure that all trainees have, at the end of the training period, a level of proficiency with the Solution necessary for smooth and uninterrupted day-to-day operation. CCJPA and Contractor shall agree on a WD basis the quantity of training (in hours), location and number of personnel to be trained.

**Project and Procurement Closeout**
Closeout begins when CCJPA accepts the project deliverables and the CCJPA and Contractor Project Managers mutually conclude that the project has met the goals established. The major focus of project closeout is administrative closure and logistics and procurement. Project closeout includes the following key elements:

1. Turnover of project deliverables to operations;
2. Closing out financial accounts;
3. Completing, collecting, and archiving project records;
4. Documenting lessons learned;
5. Planning for Post Implementation Review.

**Turnover of project deliverables to operations**
During the project closeout phase, the project team will provide early-life support of the Solution system. During this time, the project team will provide operations formal documentation to include:
1. Incident management process for supporting the Solution;
2. Technical support manuals;
3. Full API (and SDK, if applicable) documentation;
4. End user support documentation;
5. Support escalation paths.

When the period of early life support has concluded, and all deliverables turned over, operations will assume responsibility for Solution maintenance.

5.3.2.9 Closeout of Financial Accounts
During project closeout, Contractor shall close out project-related financial accounts unless future WDs are expected where these accounts are expected to be utilized. These will include:

1. Project-related bank accounts;
2. Lines of credit issued by vendors;
3. Removal of procurement authority for project team.

5.3.2.10 Completing, Collecting, and Archiving Project Records
During closeout, the project team will finalize all outstanding documentation. The Contractor’s technical writer will be responsible for collecting all final documentation and ensuring all deliverables have been delivered. The technical writer will then ensure that all finalized documents are archived.

5.3.2.11 Documenting Lessons Learned
The lessons learned from the project will be compiled from project journal entries throughout the project lifecycle. Lessons learned will also be gathered from both realized and unrealized risks in the project risk register as well as through interviews with project team members and other stakeholder as necessary. The lessons learned will be used as references for future projects and contain an adequate level of detail so that other project managers may have enough information on which to help base their project plans. The lessons learned will be categorized by project knowledge area. These knowledge areas consist of: procurement management, risk management, integration management, quality management, time management, cost management, scope management, human resource management, and communications management.

The lessons learned from the project will be contained in the organizational lessons learned knowledge base maintained by Contractor in a secure, online system accessible by web browser. This information will be cataloged under the project’s year (e.g., 20xx) and the type of project for future reference. This information will be valuable for any project manager assigned to a similar project in the future.

5.3.2.12 Post Implementation Review
The final formal activity of the project team will be to perform a formal Post Implementation Review in which CCJPA, Contractor, and its subcontractors (if applicable) will participate. The following methodologies will be employed during the review:

1. Interviewing stakeholders (e.g., Project Director, senior management, business experts, records management staff and representative users);
2. Using questionnaires or surveys;
3. Observing the Solution in operation;
4. Observing successful transfer of data from the Solution to CCJPA systems using documented APIs and other data exchange processes and methodologies;
5. Examining Solution metrics and reports generated by the OSS;
6. Examining procedures manuals, training materials and other documentation;
7. Carrying out random checks on the quality of records and control information.

The output of the review will become the basis for the final project report to be produced by the Contractor Project Manager and provided to the Contractor Project Director, CCJPA Project Manager, and all stakeholders. A copy will be placed in the project documentation archive.

5.3.3 Stage 1 Deliverables
The deliverable documents required for Stage 1 are as follows:

<table>
<thead>
<tr>
<th>Deliverable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick-Off Meeting Materials</td>
<td>Meeting agenda, minutes and project schedule in MS Project format.</td>
</tr>
<tr>
<td>Project Management Plan (PMP)</td>
<td>PMP shall include a full project plan for all tasks included in the WD SOW with all sections detailed in 5.3.2 Project Management and Implementation.</td>
</tr>
<tr>
<td>Project Plan Updates</td>
<td>Updates to the project plan, including changes to tasks and completed tasks, baseline tracking, and updates to the risk assessment.</td>
</tr>
<tr>
<td>Documentation &amp; Training Plan</td>
<td>Detailed plan for the training of CCJPA personnel in Solution operation.</td>
</tr>
</tbody>
</table>

| Status Reports                |
|-------------------------------|-----------------------------------------------------------------------------|
|                               | A weekly status report containing the following:                            |
|                               |   • A narrative review of work accomplished during the reporting period and other significant events; |
|                               |   • Status of all ongoing activities;                                       |
|                               |   • Identification of problems encountered (including issues that may impact work performance) and recommended solutions; |
|                               |   • Anticipated activity for the next reporting period;                     |
|                               |   • Updated project schedule with a two-week look ahead of activities scheduled; |

5.4 Stage 2 – System Design and Approvals
During this phase Contractor shall develop and design the Solution as defined by the WD SOW – comprising OBN components on board cars – while ensuring that all requirements as defined by CCJPA are reflected in the final design. For the purposes of this section, it is assumed that an OSS system will be developed and deployed by Contractor as part of the initial WD, and that additional work on the OSS to support subsequent WDs will be minimal.

The final product of this phase will be a working set of design drawings and selection of hardware and software that shall serve as the basis of the OBN installation on cars. To accomplish this, Contractor shall conduct the following discovery work:

5.4.1 OBN Design Preparation
This work will identify OBN installation options, basing design on architectural and engineering characteristics of the target car type(s) that conform to all referenced standards. Contractor shall identify options for radio and antenna placement, power source, and location of cable runs, and evaluate any
other requirements or constraints. Orders for items with long lead times will be placed during this phase. For certain train sets it is possible that the OBN design developed during the initial WD can be maintained for all subsequent car installations with little or no variation required in the design. Deployment on other car types or out-of-state fleets may require a new OBN assessment and design package.

5.4.2 Initial Design Plan

Contractor shall produce an initial design plan that will describe in detail the complete Solution arrangement proposed for the all cars included in the WD. The initial design plan shall provide the overall technology solution and sufficient technical details to undertake detailed logical and physical design, development, testing, and implementation of the project.

The initial design plan shall incorporate detail of the Conceptual and Logical architecture. The Conceptual Architecture shall identify and consider all high-level technology choices necessary to provide adequate confidence that the project deliverables shall conform to project requirements. The Logical Architecture shall define the processes that are required to provide the needed user functionality.

The overall initial design package shall include the following documents at a minimum:

- Overall design and major areas with keyed notes depicting the work required;
- Design consideration including value engineering propositions;
- Verification that Solution equipment and associated components are capable of meeting capacity requirements and providing rated performance in the installed environment and ambient conditions;
- Descriptions of tasks for the following phases of implementation; the tasks must be formulated independently:
  - Installation;
  - Integration;
  - Commissioning;
  - Validation and Acceptance.
- Installation documents and specifications with details of various Solution components including radios, antennas, cabling, connectors, switches, routers, and convertors;
- Interconnection diagrams with currently or soon-to-be installed on-board equipment such as OBN;
- Detailed cost estimates that provide a breakdown of all material quantities that will be used in the on-train installation, along with estimated labor hours for all installations. The material breakdown will be listed in line with the divisions of the technical specifications.

The design and all supporting documentation shall be presented as the deliverables of the initial design plan review.

5.4.3 System Requirement Specification

Contractor shall provide a System Requirement Specification (SRS) document that shall be formulated at a level of detail that fully describes the features and behavior of the entire Solution comprising OBN and OSS elements, interaction with existing systems (if applicable), and API functionality. Contractor shall submit the updated requirements to CCJPA for review for SRS compliance, which proves the ability to
meet functional, non-functional, and technical requirements, along with a Requirements Traceability Matrix (RTM). As the project progresses, any changes to the requirements shall be reflected in the requirements document and the RTM. Any changes to the requirements shall be processed through the CCJPA approved Change Control Process. Such changes shall be approved by all required stakeholders prior to bringing the changes to requirements.

5.4.4 Legacy System Support & Transition Plan
Design and installations shall require careful coordination in situations where existing legacy Wi-Fi and new OBIS systems are already installed on rail cars. Based on the condition of target cars under an individual WD, Contractor shall submit a Legacy System Support & Transition Plan to CCJPA and its partners where applicable that includes:

- Technical approach to Solution installation and system interoperability;
- Risk management and transition process from legacy Wi-Fi to Next Generation Wi-Fi taking into account that whole-train consists may comprise a mix of old and new systems;
- Test plan for mixed consist environments where legacy Wi-Fi and/or OBIS systems are present.

In all cases Contractor’s plan shall mitigate the possibility of cars being without Wi-Fi and/or OBIS services in any given train set under a WD. Contractor shall present staggered installation and interoperability options and scenarios for consideration by CCJPA and its partners; such options and scenarios shall minimize the amount of time any rail car must be taken out of service, and require CCJPA approval prior to First Train Installation (FTI) commencement.

5.4.5 Detailed Design & Final Bill of Materials
Following the formal acceptance and sign off of the concept design by CCJPA, Contractor shall produce a detailed design package showing the detailed arrangement of interior and exterior equipment, wiring routes, sub-assembly plates, and mounting hardware. An included technical report shall contain enough data for each subsystem or component to confirm the viability of the proposed solution within CCJPA’s technical, cost and schedule requirements. This package shall include, but not be limited to the following:

- Compliance matrix to show compliance with all applicable mandatory national and industry standards;
- Supporting calculations as required;
- Gauge drawings;
- Any additional relevant supporting documentation;
- Any additional drawings or data sheets as required.

The design and all supporting documentation shall be presented as the deliverables of the design review. After the internal detailed design review by CCJPA, Contractor shall integrate all agreed changes requested by CCJPA to the system detailed design package and to the final equipment Bill of Materials (BOM). Following approval the design package shall be set to ‘final’ status after the changes have been made and approved by CCJPA. The design package shall include as a minimum the models and descriptions of the various architectural and technical aspects of the system, including:

- Physical design and deployment of all Solution on-board equipment;
- Logical design of OBN and OSS software functionality, major components, and customizations;
- Informational model describing the handling of data flows, data quality, quantity, and timeliness;
- Detailed API functional description, with full list supported calls, metrics available for query by external systems, and other supporting documentation;
- Product specification sheets for equipment proposed;
- Diagrams for locations of all Solution components per car type;
- System security design;
- OSS software design (including screenshots) of content authoring and management software, and monitoring and reporting software;
- Any one-off components such as brackets that shall be developed for the specific WD;
- Cut sheets and specifications for all products and key components comprising the overall solution.

Contractor shall keep CCJPA as involved as possible through the design process to ensure that there will be no unexpected items when the final package is submitted. CCJPA shall take reasonable measures to ensure timely review and approval.

On formal acceptance and sign-off of this design, Contractor shall order the full BOM for the first brain and intermediate car installation. Materials shall include cables, brackets and all sundry items that may be required. All materials for the fleet shall be organized by Contractor who shall be responsible for:

- Procuring and stockholding all materials;
- Configuring items as required;
- Allocating and recording all serial numbers for all parts where components do not have ESNs;
- Recording MAC address of all interfaces for IP-based components;
- Recording IMEI and SIM numbers;
- Ensuring that the materials can be made available to match the defined production schedule;
- Communicating regularly with the Project Manager to ensure that any change in production rate is matched with the shipment of materials to site.

5.4.6 Stage 2 Deliverables

The deliverable documents required for Stage 2 are listed and defined as follows:

<table>
<thead>
<tr>
<th>Deliverable Name</th>
<th>Description</th>
</tr>
</thead>
</table>
| Concept Design Plan (Incorporating Conceptual, Logical and Solution Architecture, and System Requirement Specification) | This is a detailed and clear description of the proposed design that shall be implemented on a specific fleet or car type. This document captures all of the key functional areas and describes:
- Compliance with Federal/Industry and other mandatory standards;
- Fulfillment of all functional and non-functional requirements;
- The system components that will be installed;
- The areas of the vehicle that will be used to accommodate the system components;
- Assessment of impact of risks;
- This document will allow Contractor to provide an accurate work estimate and to allow CCJPA to review the proposed design before detailed design is initiated. The approval of this document is a key gating stage as following approval all long lead-time equipment may be ordered. |

CCJPA Next-Generation Wi-Fi Solution Conformed Statement of Work
### Deliverable Name | Description
--- | ---
**Detailed Design Package** | Mechanical and electrical drawings will be produced showing where equipment will be located within the vehicles, methods of fixing, cable routes, electrical and Ethernet connections to existing train systems. The level of detail shown on the drawings will clearly show where components are located, and how they are fixed in place, inside and outside the vehicle. All drawings and models of CCJPA equipment will be done in an agreed CAD format and provided in that format, and PDF, to CCJPA.

**API Documentation** | Provide documentation related to the API's available both on and off train.

**Bill of Materials** | This will be an accurate list of all items being used on the installation and will include:
- All Contractor Solution components;
- Cables;
- Fixings;
- Sundry items, i.e., sealants.

The purpose of this list is to support materials ordering; however it will be used later also, as part of the approvals submission and also as information to support maintenance activities for the life of the system on the train.

**Installation Procedure** | This will be a detailed written procedure that shall be followed by the installation staff and will describe in detail all aspects of the installation including:
- Mounting equipment;
- Routing cables;
- Electrical connections cable tests and special checks.

The document will refer also to specific tests and commissioning activities and will provide a sign-off for each car that must be undertaken when installation work is complete. All sign-off sheets and completion records will be scanned and maintained electronically and will form part of the records maintained for each vehicle installation. These will be fully accessible to CCJPA. These shall be maintained by Contractor and delivered in full to CCJPA upon approval. Following the first installation of each different car type, this document will be revisited for any required updates and photos.

**Legacy System Support & Transition Plan** | Process for supporting existing systems during WD execution.

---

### 5.4.7 Stage 2 Approvals

Documents for this stage that require CCJPA's approval **in addition to those deliverables listed above are listed and defined as follows:**

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials Report</strong></td>
<td>This report will include description of the materials content for all items being installed on a train, with a description of how these meet the fire compliance requirements.</td>
</tr>
<tr>
<td><strong>Mechanical Report</strong></td>
<td>Design calculations will demonstrate how train-borne equipment mountings comply with the mechanical strength requirements of equipment mounted to railway vehicles.</td>
</tr>
<tr>
<td><strong>Electrical Report</strong></td>
<td>This report will include all calculations relating to electrical loads, earthing, circuit breaker selection, and cable sizes for all OBN components.</td>
</tr>
</tbody>
</table>
5.5 Stage 3 – OBN Installation

5.5.1 Factory Acceptance Test (FAT)

Before the first train installation takes place (where ‘train’ encompasses a brain car and a series of intermediate cars), Contractor shall undertake a complete Factory Acceptance Test (‘FAT’), typically in a lab environment, where all hardware required for the first train, including cables, is arranged together, and a full functional test is undertaken to ensure correct operation. This validates all configurations of equipment, and also that cable terminations have been made correctly and minimizes the risk of any issues on the first train installation. The FAT shall also establish base line key metrics for ‘whole Solution’ performance and functionality against which rail car installations will be validated. These metrics shall include but not be limited to ICL throughput over multiple hops equal to an entire train set; cellular link throughput, latency, packet loss and jitter (whether as individual or aggregated links); traffic prioritization and flow control; and any other OBN configuration or function that CCJPA has specified as a technical requirement. The FAT shall also establish and validate proper functionality between OBN and OSS components, and verify that all components are reporting status, health, and availability for remote monitoring within the OSS and by external systems via API in the manner defined by the System Requirement Specification. CCJPA shall attend and participate in the FAT.

Contractor shall maintain all FAT configurations which have passed for all car types and/or equipment configurations to the extent that they differ from each other so that such that all FAT configurations can be utilized for software/firmware upgrades. As hardware configurations may change with particular car types or fleets, the FAT configurations shall be similarly updated on a WD basis.

5.5.2 Lead Time for New Work Directives

For each new WD, Contractor shall, as far as possible, identify the lead times for the equipment required as soon as CCJPA informs Contractor of the upcoming WD (but for the avoidance of doubt Contractor need not place purchase orders for a particular WD until it has received official notification to proceed with the WD and/or purchase order cover from CCJPA). Contractor shall maintain a local supply of all long lead time equipment that shall be sufficient for two (2) complete brain cars and five (5) complete intermediate car installation kits.

5.5.3 Materials Staging

Contractor shall manage equipment configuration, testing, kitting, and shipping. This shall enable Contractor to scale its deployments rapidly over multiple installations and multiple projects. This process delivers consistent, repeatable, and audited quality providing a fixed standard. Contractor’s kitting methodology will enable a modular installation approach supporting part installations where rail car availability is an issue. The key elements in Contractor’s Materials staging process will include:

- All items from vendor-supplied hardware (e.g. mobile router, APs, and antennas) to manufactured items (e.g. brackets, cable assemblies) shall be shipped from the various suppliers to the staging site(s) agreed by CCJPA and Contractor;
- All configurable items (e.g. mobile routers, cellular modems and SIMs, ICLs, switches and Wi-Fi APs) shall be configured as required;
- Following configuration, the OBN components shall be fully tested;
• All hardware shall be identified with asset identification tags provided by CCJPA. The details of these shall be recorded to identify individually equipment parts, and shall be included as part of the asset database;

• All electronics, brackets, cable assemblies, and other sundry items including fixing hardware, sealants, cable ties etc. shall be packaged into sub-assembly kits as required to suit the installation methodology required for a particular car type and/or train route;

• Equipment shall be delivered to the designated site following a schedule agreed with the Project Manager. Contractor shall hold sufficient materials to accommodate for fluctuations in production requirements or delays from suppliers (e.g. holidays, disrupted transportation links). Contractor shall establish a fixed three-month moving schedule with its suppliers;

• Issue of shipper (e.g., FedEx, UPS) tracking numbers to CCJPA Project Manager within 24 hours of shipping, and the maintenance of a shipping records on project web site with Bill of Materials, signed packing slips and other documentation in PDF format, ship and receive dates, and comments for noting missing items and path to remediation and correct fulfillment.

5.5.4 Installation Procedure

Working closely with the Contractor Project Director and Contractor Project Manager, CCJPA shall select the most suitable site for undertaking the OBN installation work on a WD basis. The CCJPA staff at that location will have the opportunity to review the design information, and decide whether to undertake the installation work themselves or have this undertaken by labor provided or subcontracted by Contractor. The first OBN installation on a train (FTI) will be undertaken by Contractor during the initial WD to allow the design to be refined and as a means of producing finalized modification instructions to be followed by whomever later undertakes the OBN installation work.

5.5.4.1 First Train Installation

The first train materials shall be delivered to the designated site to be received by Contractor, who shall be responsible for providing a safe and secure storage location within the CCJPA facility, and for checking for completeness before work starts.

The Project Manager and Contractor work supervisor shall agree with the CCJPA facilities’ management team on the detailed work schedule for the installation, including any specific requirements for location facilities (e.g., roof access or power). A written FTI plan shall be produced by Contractor showing the exact work breakdown for the first train, and be agreed upon by all parties and submitted for approval by CCJPA before work commences. A hand-over and hand-back procedure shall be agreed to establish the processes that Contractor and CCJPA follow when a set of cars is made available for modification, and then returned following modification. The procedure shall include the inspections that CCJPA shall undertake, as well as test results or paperwork that Contractor’s team shall produce to meet the local site requirements.

Contractor recognizes that there will be requirements to work around other depot activities in particular to ensure that train availability is not compromised. As a result, Contractor understands that there will be periods where staff is unable to work while critical activities are undertaken.
All team members shall have local site safety permits allowing them to undertake the required on-site work. All team members shall be introduced to the local CCJPA site supervisor who shall ensure that the safety certification is up to date, or that any additional safety and blue flag training or briefing that is required shall be provided.

The FTI shall establish the efficacy of the Detailed Design & Installation Plan for fitting of OBN components in the desired locations; this includes mobile router, ICLs, DTL, Wi-Fi APs, roof-mounted antennas, and cabling. Modifications shall be made to the design if changes need to be made to accommodate equipment in the manner described in the Detailed Design Plan. The plan shall accommodate any special methods and/or safeguards required by Contractor’s Legacy System Support and Transition Plan and include test procedures validating Solution interoperability between all cars covered by the WD.

Contractor shall undertake all tests on cabling, earth bonding and other components to verify installation quality. On completion of each car a ‘record pack’ shall be produced and shall contain a record of the installation, including all devices serial numbers and test records. The purpose of this pack is to provide clear documentation to CCJPA of the work completed and to Contractor’s asset tracking system that forms the live record for all equipment and trains. Contractor shall utilize the web-based project site to archive all records, and CCJPA and its partners shall have access to all of the installation records.

5.5.4.2 First Article Inspection

Prior to release of the first installed train set, CCJPA personnel will perform a First Article Inspection (FAI). The FAI may occur as the installation progresses, or may happen at the end of the install, at CCJPA’s sole discretion.

5.5.4.3 System Acceptance Test

On completion of the first train, Contractor shall undertake a System Acceptance Test (SAT) to validate all of the design assumptions, and allow system configurations to be finalized for the production. The results of the test will be presented in a SAT test report. Unless otherwise agreed the report will have the same format as the FAT test report.

5.5.5 As-Built OBN Design Package

Following completion of the FTI during the execution of the initial WD, the design package shall be reviewed to allow a detailed as-built OBN design package to be produced. The as-built design package shall incorporate the experience obtained from the FTI to define accurate cable lengths, equipment locations, and clear installation instructions. Contractor shall submit the production design to CCJPA for review and acceptance as before. Where there is significant deviation from the initial design, whether to brain or intermediate cars or both, then the first train shall be brought to the production standard to ensure fleet consistency. At this point the design will be considered to be final (i.e., ‘locked down’) and any subsequent changes made through a documented change control process. The project plan shall reflect the time it takes for each party to conduct their reviews and acceptance.

5.5.5.1 OBN Design Variations

WDs subsequent to the initial WD may require the OBN to be installed on cars of a different type and design than that on which the FTI was executed. In this event Contractor shall repeat the initial OBN
installation process as described in 4.5.4. *Installation Procedure* and conduct new SAT tests and reports accordingly for CCJPA review and approval.

### 5.5.6 Stage 3 Deliverables

The deliverable documents required for the OBN Installation are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBN Design &amp; Installation Plan</td>
<td>Complete set of drawings and installation process describing the location of all OBN components including mobile router, ICLs, DTLs, Wi-Fi APs, roof-mounted antennas, and RF/power cable routing, and custom brackets to be approved by CCJPA prior to installation. Installation plan shall accommodate special needs identified in Contractor's Legacy System Support &amp; Transition Plan.</td>
</tr>
<tr>
<td>FAT Specification</td>
<td>When all materials are available for the first train for any fleet type these will be arranged to replicate, as far as possible, the actual on-train installation. All of the device settings will be tested to ensure that these function as expected and a full network can be established through the train system components to the back-office systems. CCJPA shall witness this test and Contractor shall produce a test report including all results and metrics gathered.</td>
</tr>
<tr>
<td>FAT Report</td>
<td>This report will document the results of the FAT.</td>
</tr>
<tr>
<td>SAT Specification</td>
<td>The first train will be modified in accordance with the design drawings and specifications. The system will be tested in a very similar method employed on the FAT to validate all design assumptions. This test will include a User Acceptance Test (UAT), provided that the first train is kept together in a single consist by CCJPA so as to enable UAT. CCJPA shall witness this test and Contractor shall produce a test report including all results and metrics gathered. Contractor shall define the testing approach and acceptance criteria in the test plan. The document shall include step-by-step procedures used to execute each test.</td>
</tr>
<tr>
<td>SAT Report</td>
<td>This report will document the results of the SAT.</td>
</tr>
<tr>
<td>Device Configuration Settings</td>
<td>Contractor will finalize all device configuration settings for all configurable devices. Contractor will provide a definition of the configurations describing the settings, and copies of the equipment configuration files.</td>
</tr>
</tbody>
</table>

### 5.6 Stage 4 – Commissioning

Contractor shall conduct full system testing to ensure that all of the OBN, OSS and API segments and their constituent components work properly both individually and together. During this phase, extensive testing shall be performed under CCJPA supervision to verify that the system is working properly in all potential scenarios, including mixed consists comprising old and new systems as detailed in section 5.4.4 Legacy System Support & Transition Plan.

Contractor shall coordinate with CCJPA to facilitate planning and execution of all commissioning tasks. Contractor shall develop and maintain an Issues Log identifying all commissioning activities, test cases, unresolved and closed issues, and service disruptions. Contractor shall update the log as new issues come up or old issues are modified or resolved.
5.6.1 OBN Commissioning

Contractor shall perform commissioning services for the installation of all OBN materials and hardware. Materials are defined as any component of the Solutions including but not limited to mobile routers, ICLs, Wi-Fi APs, antennas, switches, power supplies, cables, and connectors. A detailed Commissioning Plan shall be submitted for CCJPA’s review and approval prior to commencing any commissioning services and activities. Commissioning services under this task verify that installation procedures meet expectations, that all Solution equipment has been physically installed per the design documents and is powered correctly, and that the material installed is new and free of damage and defects. The Commissioning process will also verify that RF propagation from ICLs and Wi-Fi APs, and DTL connectivity, throughout a car and/or consist is of acceptable quality and operating according to design. Contractor shall verify component capacities as well as quantities, measurements, and placement of components in comparison to the design documents. OBN commissioning shall be followed by the CCJPA-led Validation and Acceptance procedure on a car-by-car basis.

5.6.2 OSS Commissioning

Contractor shall verify that the OSS software performs to CCJPA requirements, and provide a Functional Matrix showing all software requirements and the test plan used to verify the functionality of the OSS, interaction with the OBN, and data flow via the API. Functional verification shall include both normal and abnormal operating conditions including verifying how an application performs when testing each component of the Solution and verifying its correct operation and expected outcome. OSS commissioning shall be followed by the CCJPA-led Validation and Acceptance procedure specific to OSS functions.

5.6.3 Commissioning of Overall Solution

Contractor shall document final system-wide performance and ensure the overall Solution performs per the design documents, installation, and integration specifications. This includes but is not limited to functional interaction between on-train and off-train components and back-office systems. The final commissioning or turnover package shall include the final punch list and status of issues. All physical assets shall be affixed with an asset tag by Contractor, and logged in the asset database.

5.6.4 Typical Commissioning Procedure (Subject to WD)

5.6.4.1 OBN

Contractor shall produce a set of commissioning and test instructions for each car type on which the OBN has been installed. On completion of the installation, Contractor or appointed representative will undertake the Commissioning Test. Where intermediate cars are being installed in the absence of a brain car, Contractor shall provide a portable brain unit to test intermediate car functionality.

The commissioning tests check all OBN materials, and full end-to-end OBN system operation, as well as integration with the existing systems (if applicable). Materials are defined as radios, antennas, switches, cabling, wiring for power, sealants for the prevention of water intrusion, mounting hardware, all fasteners, bolts, screws, strapping, proper clean up, no interference with access to already installed equipment, etc. Contractor shall verify component capacities (for example, that signals to the roof-top antennas are sufficient to ensure stable transmission of data) as well as quantities, measurements, and placement of components in comparison to the design documents. Contractor shall verify OBN operation including but not limited to:
1. Ability of OBN to acquire GPS signal and connect to cellular networks;
2. Ability of OBN to detect and interoperate with alternative backhaul systems, if present;
3. Ability of OBN to detect and interoperate with existing legacy systems, if present;
4. Measurement of key performance metrics to verify Solution meets or exceeds CCJPA requirements including but not limited to:
   - ICL channel assignment and signal strength;
   - Wireless ICL throughput measured at each hop from the mobile router;
   - Wired DTL throughput measured at each hop from the mobile router;
   - Wi-Fi AP channel assignment and signal strength;
   - Wi-Fi throughput measured from a CCJPA-approved end-user device in each car back to the mobile router;
   - Ability to load the Wi-Fi portal, authenticate, and access the Internet;
   - Page load time and round-trip ping from CCJPA-approved sites on the public Internet.

Contractor shall rectify any issues that arise until the car under test has passed the Commissioning procedure. Contractor shall undertake quality audits on a selection of cars throughout a WD production cycle to ensure that quality and consistency is being maintained throughout.

### 5.6.4.2 OBN Commissioning Test Deliverables

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBN Commissioning Plan</td>
<td>A detailed description of Contractor plan for OBN commissioning processes.</td>
</tr>
<tr>
<td>OBN Commissioning Reports</td>
<td>Individual commissioning reports for each car and train set installed.</td>
</tr>
<tr>
<td>OBN Test Plan</td>
<td>A full set of tests that that be proposed by Contractor and approved by CCJPA prior to commencement.</td>
</tr>
<tr>
<td>OBN Test Results</td>
<td>The results of the OBN Test Plan.</td>
</tr>
<tr>
<td>Updated Asset Database</td>
<td>All asset tags are logged in the asset database within 24 hours of each commissioning procedure.</td>
</tr>
</tbody>
</table>

### 5.6.4.3 OSS

It is expected that the OSS shall be designed and delivered during the initial WD and that subsequent WDS will not require significant modification to core OSS functionality. A typical WD would be adding new network elements (i.e., physical devices such as OBN components) to the OSS database. Contractor shall produce a set of commissioning and test instructions for the OSS components and back-office systems including but not limited to functionality covering:

1. Delivery of OBN component health and status data to the OSS system;
2. Generation of alerts and monitoring reports to CCJPA specifications;
3. Generation of support tickets and proper routing and escalation of support issues;
4. Accessibility of real time and historical data from external systems via APIs.

### 5.6.4.4 OSS Commissioning Test Deliverables

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
</table>

CCJPA Next-Generation Wi-Fi Solution Conformed Statement of Work
5.6.5 Validation and Acceptance
On completion of either individual OBN or overall OSS commissioning, the CCJPA-led Validation and Acceptance testing will be carried out. No car may go into service until this process has been successfully completed and approved by CCJPA.

5.6.6 Post-Commissioning Period
On completion of Contractor commissioning and validation by CCJPA, cars will enter a shakedown period of two weeks during which they will be in normal operation and during which Contractor shall diagnose the full Solution to ensure that no issues have arisen as a result of actual operation.

5.6.7 Final Commissioning Report
At the completion of a WD, Contractor shall submit a Final Commissioning Report that includes an Executive Summary, list of participants and roles, brief WD description, overview of commissioning and testing scope, and a general description of testing and verification methods. The report shall contain, at a minimum:

1. Commissioning plan;
2. Completed commissioning, pre-functional, and functional checklists;
3. Copies of all testing logs and documentation;
4. Copies of all commissioning issue reports;
5. Asset verification reports;
6. Final commissioning schedule.

The report shall be a stand-alone document that completely explains the commissioning processes and logic on a WD basis. This document shall contain copies of all design and O&M documentation used in the commissioning process. The report shall be organized and presented in PDF format for approval by CCJPA.

5.6.8 Stage 4 Deliverables
The deliverable documents required for the Solution Commissioning stage are listed and defined as follows:

<table>
<thead>
<tr>
<th>Acceptance of Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document Type</td>
</tr>
<tr>
<td>Commissioning Plan</td>
</tr>
</tbody>
</table>
### Acceptance of Solution

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commissioning Procedure</td>
<td>This test document will describe the function tests undertaken for all Solution components. Will include a functional matrix showing all requirements and the tests used to verify the functionality. Contractor shall define the testing approach and acceptance criteria in the test plan. The document shall include step-by-step procedures used to execute each test.</td>
</tr>
<tr>
<td>Test Results: Functional</td>
<td>These signed-off test sheets shall show the completed tests done in accordance with the Commissioning Procedure.</td>
</tr>
<tr>
<td>Asset Tracking Database</td>
<td>This document shall provide a record of all materials installed with individual fields including but not limited to:</td>
</tr>
<tr>
<td></td>
<td>• Equipment type and part number;</td>
</tr>
<tr>
<td></td>
<td>• Serial number (Electronic Serial Numbers (ESN)) where available shall be recorded automatically by the OSS;</td>
</tr>
<tr>
<td></td>
<td>• CCJPA asset tag number;</td>
</tr>
<tr>
<td></td>
<td>• Revision number, if applicable;</td>
</tr>
<tr>
<td></td>
<td>• Configuration reference, if applicable;</td>
</tr>
<tr>
<td></td>
<td>• Other references as required;</td>
</tr>
<tr>
<td></td>
<td>• Location in car;</td>
</tr>
<tr>
<td></td>
<td>• Warranty dates;</td>
</tr>
<tr>
<td></td>
<td>• Expected lifespan of asset;</td>
</tr>
<tr>
<td></td>
<td>• Raw cost of asset.</td>
</tr>
<tr>
<td></td>
<td>In addition, the document shall provide a list of software licenses where applicable, which shall include:</td>
</tr>
<tr>
<td></td>
<td>• Software license denomination and/or module name;</td>
</tr>
<tr>
<td></td>
<td>• Revision number, if applicable;</td>
</tr>
<tr>
<td></td>
<td>• Upgrade history;</td>
</tr>
<tr>
<td></td>
<td>• Configuration reference, if applicable.</td>
</tr>
<tr>
<td>Audit Procedure</td>
<td>This document will define the inspection and test procedure that will be followed to undertake sample train and wayside site quality audits.</td>
</tr>
<tr>
<td>Validation &amp; Acceptance Reports</td>
<td>A report supplied by CCJPA for each car, confirming the validation procedure and pass criteria have been met successfully.</td>
</tr>
<tr>
<td>End of Work Directive</td>
<td></td>
</tr>
<tr>
<td>Full Commissioning Report</td>
<td>Report will include an Executive Summary, list of participants and roles, brief WD description, overview of commissioning and testing scope, and a general description of testing and verification methods.</td>
</tr>
</tbody>
</table>

#### 5.7 Transition from Delivery to Service Support

When the shakedown period has been successfully completed, the installation for the individual cars shall be considered to be complete. The responsibility for the end-to-end system shall at this point be handed over to Contractor's Operation and Maintenance (O&M) team; Contractor's O&M offering is detailed in section 6 Operation, Maintenance and Support. The project structure changes from this point where the delivery structure, defined above, was only required to bring cars to where they were successfully installed and ready for service. All design and installation information and records for each car will then pass to Contractor's O&M team who are responsible for the following activities:

1. Monitoring system performance 24/7/365 to identify devices that have failed or that require attention;
2. Managing the asset database and keeping it continually up to date in order to track all materials, warranties, and repair activities;
3. Mobilize second line (Tier 2) support personnel to undertake issue investigation and component change out as required;
4. Report on system operation, system performance, defect analysis, usage, and other reporting as required;
5. Manage any routine updates to the system configurations as required.

The service support team shall report directly to the CCJPA Wi-Fi Services team and other parties as required. Contractor shall create a standard reporting structure so that the Solution performance can be monitored to identify any general issues to be addressed on a network-wide, individual car, consist, or train set basis.

5.7.1 Manuals & Documentation

Contractor shall produce a full set of maintenance and user manuals for each WD to accompany the installed system. As part of the WD rollout Contractor shall provide the maintenance documents as input to, and in support of, Contractor’s support activities. Documentation shall include a technical operation and maintenance manual that describes the procedures for system administration, including product specifications and warranty information for all materials installed, configuration of cars and specific equipment settings, configuration and use of API(s), user account setup and maintenance, and all other relevant technical information to ensure technical understanding of the final solution. Manuals shall be available in electronic form and shall become the sole property of CCJPA. Contractor shall demonstrate that all documentation has been through a thorough quality assurance process prior to submission for CCJPA approval. No training shall commence until all documentation has been reviewed and approved by CCJPA.

5.7.2 Training

Contractor shall provide a Training Plan addressing operational, administrative, and technical training for users of the Solution. CCJPA will review and approve the training plan prior to the commencement of training. Contractor shall provide hands-on training using a real-time environment.

Contractor shall work with CCJPA to define the number and length of sessions, the target audience, and the training channels (e.g., classroom versus online), and the number of CCJPA personnel to be accommodated for training. Contractor shall provide training courses including manuals and documentation that cover the use and maintenance of the Solution. Training manuals shall include a complete operator’s manual as well as a quick reference guides for daily system operation. Contractor shall deliver the training courses to CCJPA personnel and is responsible for on-site training as required to fully allow train personnel to efficiently perform all necessary Solution functions. All training materials and user manuals will be available both in electronic and paper form.

Contractor shall provide training and documentation to CCJPA departments as deemed necessary during the installation phase that includes but is not limited to specifications for vibration, heat, electrical and radio interference. Contractor shall provide training for CCJPA personnel that will include:

1. Navigation through the materials;
2. Daily system tasks and maintenance;
3. Configuration and administration;
4. Troubleshooting common problems;
5. Documenting and reporting problems;
6. Lab exercises;
7. Frequently Asked Questions (FAQs);

Contractor shall provide a bi-weekly training report documenting the user training provided to CCJPA personnel. The report shall include total CCJPA personnel trained in that period and year-to-date, and number of classes performed that period and year-to-date.

Should CCJPA choose to have OBN installations carried out by CCJPA (or train maintenance) staff, Contractor shall provide sufficient training to enable CCJPA to conduct OBN installations.

5.7.3 Warranty Transition Plan

In the case of a service contract where there is no transfer of asset ownership to CCJPA, Contractor will be responsible for all defect repairs for the period of that contract while ensuring that CCJPA are advised of any equipment failures and exchanges through an agreed service management process.

In the case of a capital sale or transfer of ownership of hardware to CCJPA, an asset’s warranty period commences either at the point of final acceptance of the Solution by CCJPA, or – in the case of a replacement component – when the asset has been installed and verified to be operational. Contractor shall develop a Warranty Transition Plan to enable and facilitate a streamlined transition from deployment to operation. Contractor shall assume O&M responsibilities during the manufacturer’s warranty period. At the end of the manufacturer’s warranty period, Contractor shall transfer the maintenance of the Solution to CCJPA Wi-Fi Services team or chosen service provider. Contractor shall work closely with CCJPA’s representatives to assure a smooth transition. After warranty is expired, CCJPA shall determine further support requirements, if needed. Contractor shall continue to maintain OBN software running on trains, and OSS systems on virtual data center servers. Contractor shall enter and maintain warranty information as Configuration Items in the Asset Database; see section 6.7.7 Asset Database & Configuration Management for more detail.

5.7.4 Deployment Acceptance and Closeout

Upon CCJPA’s acceptance of the deployment, Contractor shall request in writing a review by the CCJPA project manager for final signoff. After the satisfactory final completion inspection and CCJPA’s concurrence, Contractor shall secure the required signatures and transmit proper notice to CCJPA along with the required guarantees, affidavits, releases, bonds, escrow, and waivers. Contractor shall certify in writing that all work has reached final completion in accordance with the WD documents and that the final estimates of payment to Contractor are correct. Contractor shall transmit to CCJPA all closeout documents as defined in the contract, and participate in an overall lessons learned session to identify opportunities for improvement.

5.7.5 Stage Deliverables

The deliverable documents required for the transition to O&M stage are listed and defined as follows:
<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Support Plan</td>
<td>Contractor shall design a Service Support Plan as detailed in Section 6 Operation, Maintenance and Support.</td>
</tr>
<tr>
<td>Technical Support &amp; User Manuals</td>
<td>In these documents, Contractor shall describe the procedures for system administration, including configuration for specific deployment, network, and environmental settings, user account setup and maintenance, and all other relevant technical tasks.</td>
</tr>
</tbody>
</table>
| Equipment Installation and Maintenance Manuals | Contractor shall provide installation and maintenance manuals in Adobe Portable Document Format (PDF) to be used by CCJPA and other system users to maintain and support the OBN, OSS, and API segments in the event CCJPA elects to maintain its own system post-implementation. CCJPA shall be permitted to make additional copies of the installation and maintenance manuals for CCJPA needs. Manuals shall include:  
  - Detailed specifications and drawings;  
  - Detailed installation diagrams;  
  - Maintenance procedures including, but not limited to, removal, installation, cleaning, and safety precautions;  
  - Complete electrical schematics with narratives describing logical operation, drawings of components, and wiring diagrams. |
| Maintenance Documentation           | Maintenance documentation shall describe how to identify and change-out faulty equipment. It shall include but shall not be limited to:  
  - Component change specification;  
  - Fault finding guide;  
  - Test record sheets;  
  - RMA procedure;  
  - Routine maintenance. |
| Personnel Training Plan             | Training Plan shall include but not be limited to:  
  - Classroom and/or online training sessions – number of sessions and personnel accommodated to be agreed;  
  - Supporting training materials in PDF format;  
  - Bi-weekly training report. |
| Warranty Transition Plan            | Warranty Transition Plan shall include but not be limited to:  
  - Detailed migration path from Contractor to CCJPA at end of manufacturer’s warranties, where applicable;  
  - Contractor’s continuation of OBN, OSS and API software and service support. |
| Deployment Acceptance Documents     | Documentation shall include:  
  - CCJPA Project Manager sign-off sheets;  
  - Delivery of all outstanding project records to CCJPA;  
  - ‘Lessons Learned’ report. |
6 Operation, Maintenance and Support

Two different options are available for Contractor to deliver equipment and services to CCJPA based on either a capital procurement or as a service model. Depending on the option exercised, the support plan may need to be defined to reflect the responsibilities of each. Some aspects of the requirements defined below may not be applicable under the service model approach (for example spare parts and warranty) however Contractor is still required to provide the appropriate details so that CCJPA can assess readiness and also any risks that could affect system availability.

Upon CCJPA's acceptance of a working solution for a given WD, Contractor shall transition to the role of maintaining the Solution. Contractor shall formulate a Service Plan that takes into consideration component and system operating procedures, and is structured in a logical, sequential and efficient manner to include protocols, forms, checklists, and procedures to maintain centralized documentation. The Service Plan shall include a methodology for tracking deployed and spare materials, warranties for all materials, schedule of service activities and bi-weekly reporting procedures. The plan also shall define the resources, processes, and procedures used to support the Solution's functional operation, including interactions with CCJPA personnel to log, track and resolve issues. CCJPA shall have full visibility into the status of warranties, spare parts and service tickets through direct access to the management system and regular reporting on these activities at system, rail car and back-office levels.

6.1 System Support – Scope of Services

Contractor shall be responsible for:

- Maintaining hardware components installed by Contractor to enable Solution functionality comprising OBN, OSS and API segments;
- Managed virtual data center components;
- The software and firmware running on Solution components, and on-going updates;
- The end-to-end logical service from the on-board equipment to back-office servers;
- Maintaining, in partnership with CCJPA, the cost pro forma for the variety of cost categories;
- Management and overall control of spare Solution components and parts.

Contractor shall deploy a performance-based maintenance approach against an SLA defined in 6.4. Service Level Agreement (SLA) of this document. The managed support service shall comprise the following service elements:

- Service desk for Solution support ('Tier 2') – Remote investigation and attempted resolution of incidents escalated to Contractor by CCJPA Wi-Fi Services personnel;
- Field Engineering Support ('Tier 3') – On-site support to investigate and resolve issues on trains;
- Specialized support service teams for software and hardware ('Tier 4').

Maintenance spares, trained personnel (certified and experienced), software support and other resources necessary to fully maintain and support the entire Solution shall be made available for the full warranty period, starting from the date of initial service. Contractor's performance of this managed service will be measured by the Service Level Agreement (SLA) and Key Performance Indicators set out in this document.
6.2 Warranty Management

In the case of a capital sale or transfer of ownership of hardware to CCJPA, Contractor shall warrant all Solution components comprising hardware and software for a minimum one-year period. Under the terms of a service based contract then CCJPA assumes that all failed and defective parts that are replaced on the vehicle will be replaced by Contractor. Warranty will cover all parts, labor, shipping and other costs related to preparing and installing replacement parts. Any and all additional manufacturer’s warranties should be provided. Due to cost implications associated with equipment replacement, it is critical that Contractor keep accurate and timely updated records in the asset management system as the warranty management process relies heavily on that system.

Two critical attributes associated with the Configuration Item (‘CI’) records are ‘Warranty Start Date’ and ‘Warranty End Date.’ These dates are based on final acceptance of the equipment and will be accurately captured and logged. This information will then influence the manner in which Contractor responds to a CI failure that requires replacement. A CI under warranty will enter into the Returned Materials Authorization (RMA) process. Components that cannot be repaired are handled differently based on warranty status; warranted CIs will be replaced at Contractor’s cost, while CCJPA will determine whether to replace individual non-warranted CIs at CCJPA’s cost. Contractor shall report monthly on all Warranty Management activities. The reports will show (at a minimum):

- Number of RMA events for prior month;
- Type of CIs affected;
- RMA ticket quantity;
- Comparison to other months (trending);
- Incidents associated with RMA events.

6.2.1 Deliverables for Warranty Management

Where applicable the deliverable documents required for the Warranty Management, in addition to those required by 4.7.3. Warranty Transition Plan, are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warranty Transition Plan</td>
<td>Written End-of-WD plan to enable and facilitate a streamlined transition from deployment to operation.</td>
</tr>
<tr>
<td>RMA Process</td>
<td>Detailed explanation and steps for RMA process.</td>
</tr>
<tr>
<td>Monthly RMA Report</td>
<td>This report will document all RMAs in the prior month.</td>
</tr>
</tbody>
</table>

6.3 Service Plan

Contractor shall formulate a service plan that takes into consideration component and system operating procedures. The service plan shall be structured in a logical, sequential and efficient manner and shall include protocols, forms, checklists, and procedures to maintain centralized documentation. The service plan shall include a methodology for tracking deployed and spare materials, warranties for all materials, schedule of service activities, and bi-weekly reporting procedures. The plan also shall define the resources, processes, and procedures used to support the Solution components on trains and in the virtual data center. The service plan shall include input from CCJPA personnel. At minimum the Plan shall include:
- 24/7/365 SLA;
- Response time < 1 minute from automatic or human fault identification, and initial call response < 3 minutes;
- Fault prioritization as defined in section 6.4 Service Level Agreement;
- Trouble ticket management with customer portal access;
- Real-time network monitoring;
- Remote fault diagnostics and resolution;
- Service management with escalation;
- System performance monitoring and reporting tools;
- Asset, Warranty, and RMA management;
- Automatic Customer notification emails.

The service terms referred to above are defined as follows:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA</td>
<td>Service Level Agreement (SLA) denotes the minimum service level defined in section 6.4 Service Level Agreement.</td>
</tr>
<tr>
<td>Response Time</td>
<td>Time to begin investigating a potential fault, based on SLA's defined in section 6.4 Service Level Agreement.</td>
</tr>
<tr>
<td>Fault prioritization</td>
<td>Fault prioritization is defined in section 6.4 Service Level Agreement.</td>
</tr>
<tr>
<td>MTTR</td>
<td>Mean Time To Repair.</td>
</tr>
</tbody>
</table>
| Trouble ticket management   | To ensure all faults (including faults found through monitoring/alerts and service calls) are logged and are maintained during fault resolution, the following information will be captured at minimum:  
  - Trouble Ticket Number;  
  - Vehicle/Site location;  
  - Date & Time of fault raised;  
  - Fault prioritization;  
  - Fault resolution;  
  - Date & time of resolution;  
  - Name of reporting person (if applicable)  
  - Fault aging (reporting). |
| Remote fault diagnostics and resolution | Fault diagnostics and resolution via fault troubleshooting will be processed by Contractor Service Desk. |
| Service management with escalation | A service manager assigned to the portfolio will act as a point of contact to provide detailed feedback and any escalations. |
| Service reporting           | A range of reports will be available and will be tailored to CCJPA's requirements, including but not limited to Incident Aging, Fault Priority, and RMA History. |
| Asset warranties and RMA management | Return Materials Authorization is the ability to manage faulty equipment through a returns process, and to have spares stock available to be dispatched at the earliest opportunity to ensure the service is operational for the maximum available time. Warranty status will be managed by Contractor. |
| Access to ticket system     | CCJPA will have direct access to Contractor trouble ticketing system and will be able to view tickets and run reports. CCJPA will need access to open trouble tickets and read only access to run reports via a web-based self-service portal component of the OSS. |
6.3.1 Deliverables for Service Plan

The deliverable documents required for the Service Plan, are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Plan</td>
<td>Written Service Plan for component and operating service procedures.</td>
</tr>
</tbody>
</table>

6.4 Service Level Agreement (SLA)

Contractor shall provide the standard offered services levels aimed at incident and problem management. This SLA will be used to ensure that the system is available when required by CCJPA, and it will be delivered to the agreed standards. CCJPA and Contractor shall review the Service Desk classification of faults by priority on an ongoing basis. The resolution times stated below are used for wayside sites that can be accessed as needed, and when train sets are available for incident resolution at predetermined maintenance facilities, and the cars containing Solution components are made available to Contractor for access. All on-site resolution times are strictly dependent on availability of the vehicle or access to the wayside, as well as – in the case of rail cars – receiving accurate information from CCJPA regarding the intended location of vehicles at (and for) the times where a Contractor field service engineer is required on-site.

<table>
<thead>
<tr>
<th>NEXT-GENERATION WI-FI O&amp;M SERVICE LEVELS</th>
<th>Hardware and Infrastructure Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority Level</td>
<td>Response Time</td>
</tr>
<tr>
<td>Priority 1 &quot;Critical&quot;: Wi-Fi Service Failure</td>
<td>______________________</td>
</tr>
<tr>
<td>Priority 2 &quot;High&quot;: Vehicle Failure</td>
<td>______________________</td>
</tr>
</tbody>
</table>

10 Only where equipment sold to CCJPA
### System Failures

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Response Time</th>
<th>Resolution Time</th>
<th>Example Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority 2: Software Failure</td>
<td>[underline] to begin remote investigation after identification of a potential fault from any source.</td>
<td>Remote Resolution: [underline] to start resolution after ticket raised</td>
<td>Overall degraded performance in any service</td>
</tr>
<tr>
<td>Priority 3: OSS Infrastructure</td>
<td>[underline] to begin remote investigation.</td>
<td>Resolution: [underline] after response time ends. For all redundant component failures.</td>
<td>Non-service affecting OSS redundant hardware failure</td>
</tr>
<tr>
<td>Priority 4: Informational</td>
<td>[underline] to begin remote investigation.</td>
<td>Remote Resolution: Resolution time is not applicable as Priority 4 tickets are not fault-related. If a fault is identified, the priority will be adjusted on a per-ticket basis.</td>
<td>Non-service affecting requests. OSS account creation request, OBN system assistance, service desk ticketing issue</td>
</tr>
</tbody>
</table>

Table 1: Service Levels

### 6.4.1 Deliverables for SLA

The deliverable documents required for the SLA, are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Service Level Agreement</td>
<td>Written and detailed SLA with priority levels, response times, and resolution times.</td>
</tr>
</tbody>
</table>
6.5 Support Plan

Contractor shall provide centralized warranty, spare part, and service ticket management. CCJPA shall have full visibility into the status of warranties, spare parts, and service tickets through self-service web portal access to the management system(s) and regular reporting on these activities at both the system and train level.

Maintenance spares, trained personnel (certified and experienced), software support, and other resources necessary to fully maintain and support the entire system shall be made available for the full warranty period, starting from the date of Production Readiness Acceptance. Contractor shall provide such service twenty-four (24) hours per day, seven days per week.

Back up and spare parts shall be specified and stored in specific CCJPA or Contractor locations, as approved by CCJPA. Contractor shall have a centralized system for tracking the location and warranty of all deployed and spare parts.

Contractor shall perform all its own on-site maintenance and bear all additional costs associated with expediting manpower or materials to effect repairs. Contractor may use subcontractors approved by CCJPA in the execution of maintenance activities. Contractor shall provide a Defect Failure & Root Cause Analysis for the failed equipment and replenish the spare to CCJPA within one week.

In addition to the O&M central management function Contractor shall provide on-site resources to conduct the following activities:

- Dispatch qualified Field Technicians within the contracted SLA response times;
- Confirm fault diagnosis and troubleshoot to determine the root cause of the failure;
- Request and receive spare units or parts not stored on-site;
- Affix CCJPA asset tag on replacement and/or spare parts whether in stock or deployed;
- Replace defective units or parts;
- Dispose of defective units or send for repair as appropriate;
- Communicate with CCJPA personnel to confirm repaired unit is on line;
- Update asset tag information in OSS reflecting in- or out-of-service status;
- Provide monthly reports of on-site activities.

In addition, Contractor shall indicate how it shall provide additional support, including Original Equipment Manufacturer (OEM) support, for issues beyond the Field Technicians’ ability to solve.

Contractor shall submit a support and maintenance plan that defines how each of these services shall be provided. Such support services shall be available in all locales and regions served by CCJPA.

6.5.1 Field Support & Maintenance

Contractor shall have technicians within a reasonable distance of Solution service areas to enable response times stated in the service level agreement are met. Technicians will be equipped with a vehicle appropriate for their assignments. Each vehicle will be equipped with tools, test equipment, and safety equipment appropriate for the assignments anticipated for that vehicle. The vehicles will be equipped with sufficient spares to allow the team to proceed directly to a work site and be ready and able to perform required maintenance or replacement.
The vehicles will have a secure lock box sufficient to assure the security of all spares, tools, and test equipment. The technicians will have a laptop computer with the proper cabling and software to interface with the field equipment. This will allow them to engage with Contractor’s network operations center via the OBN and in the event of OBN failure via a commercial cellular data network. The laptop computer should contain all reports and forms required to complete any work effort.

Contractor shall employ an approach that involves swapping parts of all defective or suspect equipment with new and/or certified parts, so that parts removed from service are ticketed in the field and returned to the NOC for test, RMA, and/or disposal. The return of a piece of equipment shall result in a replacement being supplied to the vehicle's inventory. The vehicle’s inventory will suffice to completely re-equip a single rail car (including mobile router, ICLs, switches, Wi-Fi APs, cables, connectors and other consumables) and all team members shall have been trained to do the same.

Contractor shall comply with all CCJPA rules and procedures for accessing Solution components and in providing field support within the CCJPA and partner maintenance facilities.

6.5.2 Deliverables for Support Plan
The deliverable documents required for the Support Plan, are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support &amp; Maintenance Plan</td>
<td>Written and detailed plan for all Solution components provided by Contractor.</td>
</tr>
<tr>
<td>Defect Failure &amp; Root Cause Analysis</td>
<td>Report for failed component.</td>
</tr>
<tr>
<td>Service Repair Reports</td>
<td>Monthly report on service repairs, and back-up and spares usage and inventory levels.</td>
</tr>
</tbody>
</table>

6.6 System Performance & Reliability Monitoring
Contractor shall undertake system performance and reliability monitoring, and will:

- Remotely respond to Solution issues and alerts 24/7/365;
- Provide field-based maintenance for all OBN equipment and OSS systems;
- Provide remote troubleshooting to assist with problem diagnosis and correction;
- Respond to CCJPA personnel with regards to system functionality and operating procedures;
- Proactively monitor systems and automatically recover from problems;
- Provide system software updates to improve performance and reliability;
- Use Contractor or CCJPA diagnostic systems to monitor communications system;
- Provide hourly updates via written report of reported high priority issues;
- Provide monthly reports that show conformance with deviation from the SLA.

6.6.1 Network Operations Center (NOC)
Contractor shall provide a NOC, the purpose of which is to provide CCJPA with a high availability, mission-specific Preventative Maintenance Programs (PMS) facility. This facility is designed to execute customized PMS with integrated Monitoring, Planned and Predictive Maintenance, supported by a Tier 2 and Tier 4 Demand Maintenance Team, ready to be deployed as required, to minimize the occurrence and impact of down time for the industry’s mission critical IT components.
Contractor shall operate the NOC 24/7 and together with the cloud-based OSS offer trained Tier 2 (Service Desk and System Administrators) and Tier 4 (Application and System Engineers) personnel. Contractor shall provide a system with monitoring parameters, thresholds and hurdles, reports (both ticket and status reporting), trend analysis and Tier 2 and Tier 4 Demand Maintenance.

6.6.2 Preventative Maintenance & Monitoring

Contractor shall implement a proactive approach to support for the Solution. Metrics, existing under ticket condition green, will be monitored as part of the routine maintenance procedures with trend analysis and review of daily performance determining if preventive maintenance is indicated. This will provide the ability to start support prior to Severity Level 1 and 2 conditions and prevent issues before they start.

Contractor shall monitor software and hardware on all Solution segments, whether constantly moving and/or geographically distributed, or static. Contractor shall notify CCJPA of both the content and the timing of Planned Maintenance effort and that appropriate approvals are obtained from CCJPA before execution.

Contractor shall provide monitoring of all OBN, OSS, and API segments and of constituent components and applications using a variety of tools and techniques. Each item under this effort will be monitored based on actual versus target for system performance factors. Automated notifications will be produced when the actual departs from specification.

The OSS shall also monitor and report on Wi-Fi and DTL element status, health, availability and RF conditions within an individual car, to mitigate RF signal interference and channel conflicts on APs and wireless ICLs. The Solution shall create an alert when RF issues are detected and generate a report for action. Contractor shall detail the RF health capabilities of the Solution, providing screen shots of system functionality where appropriate.

6.6.3 Reporting

CCJPA and its Wi-Fi Services personnel shall be able to create reports at any time on demand both (a) from within the Solution’s OSS segment via the self-service web portal using Contractor’s proprietary tools, and (b) using real time and historical data received via API calls. It shall not be necessary for CCJPA to require Contractor to generate reports on its behalf, unless there is a temporary failure in either of the two report-generating methods described above. These requirements cover all functions of the OSS including but not limited to system, segment and component status, health, performance, and availability. The ability to create reports shall extend to service desk ticketing, warranty, and asset and configuration management functions.

Contractor shall provide CCJPA with training for system access and the creation and export of all report types.

6.6.4 Data Repository

Contractor shall store all system reports in an online document history repository with an appropriate search engine, and data feed via API. CCJPA will have full access to this repository for searching and retrieving all information developed under this effort, or via raw data feed for import to CCJPA systems via one or more API. This shall include but is not limited to:

- Completed Work Orders performed on site;
- O&M documentation related to incident reports;
- Report Logs of damaged components and correspondence with manufacturer regarding replacement of damaged components;
- Report Logs of warranty issues and correspondence for defective components;
- Report Logs with certification of component model numbers and verification of component installations for asset management purposes.

Contractor shall retain all data generated by the Solution for a minimum period of eighteen months, provided an archive to CCJPA on a quarterly basis in a format to be mutually agreed by Contractor and CCJPA prior to contract commencement.

### 6.6.5 Deliverables for System Performance & Reliability Monitoring

The deliverable documents required for System Performance and Reliability Monitoring are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Performance Reports</td>
<td>Regular written reports on Solution performance and reliability containing the elements defined in the approved SLA and indicators reported in UAT testing results.</td>
</tr>
<tr>
<td>O&amp;M Database</td>
<td>Database of O&amp;M documentation and verification of completeness and conformance to project specifications.</td>
</tr>
<tr>
<td>Training</td>
<td>Training of CCJPA personnel on performance monitoring system.</td>
</tr>
</tbody>
</table>

### 6.6.6 Key Performance Indicators

Contractor shall use Key Performance Indicators (KPIs) to baseline and report the Service Model operations; these KPIs will include but not be limited to:

- Availability of all on-train OBN components;
- Availability of all OSS systems and applications, and API segment;
- Service Management statistics such as Mean Time To Resolve (MTTR) and Mean Time Between Failures (MTBF).

#### 6.6.6.1 Key Performance Indicators for OBN Elements

The primary KPI for the OBN elements will be reported using tiered levels of granularity. Availability of primary components will be presented as an average across the network and will allow drill-down to individual OBN components, e.g. mobile routers, ICLs, switches, DTL, Wi-Fi APs, and other IP-based components. These reports will be available for CCJPA to run at any time.

The availability KPI will be measured according to a formula based on the following metrics:

- $t$: Hours of operational time;
- $c$: Number of components of a given type;
- $d$: Hours of operational time in which the component was reported non-functional by the OSS.

The formula for calculating this availability will be:
\[ \frac{(t + c) - d}{(t + c)} \]

Note: Failures of the Solution due to an outage of train power or third party systems should be measured against those systems’ KPIs and not against the Solution KPIs.

The following table illustrates how KPIs are expressed for individual components of OBN elements. All availability KPIs for all OBN equipment will be calculated as a relationship to the time in scheduled service.

<table>
<thead>
<tr>
<th>Component</th>
<th>KPI</th>
<th>Expressed As</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Router</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
<tr>
<td>Cellular Modem</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
<tr>
<td>Wireless ICL</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
<tr>
<td>Wired ICL (DTL)</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
<tr>
<td>Wi-Fi Access Point</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
<tr>
<td>Ethernet Switch</td>
<td>Measured continuously (a measure taken at least every minute)</td>
<td>Percentage uptime as a ratio of time in service and time operational.</td>
</tr>
</tbody>
</table>

6.6.6.2 Key Performance Indicators for OSS Element

The OSS elements will contain a number of components as proposed within Contractor’s Solution. Contractor will measure the KPIs for OSS element as follows:

Based on the performance relevant to the equipment and services provided in the OSS location(s), the following KPIs will be measured according to the following criteria:

- Uptime is derived as a function of availability of OSS application servers, network appliances, and data center ingress / egress portal peering, notwithstanding pre-approved maintenance windows.
- Availability of the OSS element will be subject to the following KPIs:
  - OSS application services (at virtual data center defined by WD).
  - OSS data center hardware (at virtual data center defined by WD).
  - availability (at virtual data center defined by WD).

The availability of data center hardware and application services will be calculated according to the following formula:

\[ \frac{t - d}{t} \geq \text{required availability} \]
where:

- \( t \): Hours of operational time in hours
- \( d \): Non-functional hours

### 6.7 Service Desk and Other Support Services

CCJPA’s Wi-Fi Services help desk will provide Tier 1 phone and email support to train crews, conductors and other personnel who need to report issues regarding the Wi-Fi experience on trains, including those reported to train staff by passengers. An 800 number will connect callers to CCJPA help desk personnel 24/7/365 who will attempt to resolve issues with callers. In the event that an issue cannot be resolved, CCJPA Wi-Fi Services will escalate the issue to Contractor’s Tier 2 Service Desk which will:

- Provide Tier 2 phone and email based technical support 24/7/365 to CCJPA’s Wi-Fi Services help desk personnel who require escalation of issues for resolution by Contractor;
- Provide a ticket management system for issue submittal, tracking, resolution, and historical reference;
- Provide remote troubleshooting to assist with problem diagnosis and correction;
- Provide access to monthly service desk reports which shall include:
  - All known software and hardware defects that affect functionality and security of applications and supporting software;
  - Timelines for issue resolution and system patches.
- Provide service desk call statistics on a monthly basis.

Contractor shall perform and manage the following tasks:

- Answer all incoming calls and emails from CCJPA personnel within SLA limits;
- Obtain sufficient detail of issues to create an incident ticket and commence remediation;
- Provide solutions and take ownership of problems until resolution;
- Escalate issues to Contractor’s Tier 3 or Tier 4 personnel as required;
- Keep track of all open issues until resolution and ticket closure.

All phone calls to Contractor’s Tier 2 Service Desk shall be recorded. It shall be possible at minimum for CCJPA Wi-Fi Services personnel to submit an email to Contractor’s Tier 2 Service Desk containing information about an issue. Contractor’s ticket management system shall be capable of automatically receiving issue emails and creating an incident ticket containing the detail from the CCJPA email. In addition to phone and email submission of issues, CCJPA seeks the ability to submit via an API.

Contractor shall extract data from the automated tracking system once per calendar month and make available to CCJPA via the self-service portal an incident report presenting and summarizing that data.

#### 6.7.1 Incident Progression

After an issue is reported to Contractor by CCJPA Wi-Fi Services help desk, Contractor Tier 2 staff shall work directly with the CCJPA personnel to resolve the issue within SLA boundaries. If the issue cannot be resolved, Contractor shall escalate it to Tier 3 or Tier 4 staff as appropriate.
6.7.2 Ticket Management System

Contractor shall provide a ticket management system that shall offer a central view of all outstanding tickets and their status to Contractor and CCJPA Wi-Fi Services personnel. The ticket management system will allow for a paper trail into both current and historical issues allowing for analysis of Contractor's processes and the identification of re-occurring issues for consideration by CCJPA and Contractor personnel. Information contained within the ticket management system shall be automatically extracted and reformatted by Contractor into a formal report sent to CCJPA on or before the 15th of each month, for the period of the prior full calendar month.

Contractor will be using its Incident Management System. This is an on-line system and CCJPA and other 3rd parties can be given access to the system to see the status of the Incidents, Problems, Changes and Service Requests. CCJPA will be given access to the Contractor's system to access incidents and to view the status of Incidents.
Incidents are categorized within [ ] and as an example, the table below shows the typical Priority allocated to an Incident based on the impact the incident has on the service.

[ ] will allow real-time access to CCJPA to a set of standard reports and dashboards that can be customized to fit additional requirements. Some of the reports available are:

**Incident Management**

- Number of incidents per month
- Number of incidents by priority
- Mean time to resolve incident
- SLA breaches including explanation where SLA has been breached

**Change and Release Management**

- Changes per month
- Emergency changes per month
- Unplanned changes
- Incidents related to changes
- Incidents related to failed releases

**Problem Management**
6.7.3 NOC Support

The NOC described in section 6.6.1. Network Operations Center (NOC) will provide Tier 2 support and a central location for all help desk items.

6.7.3.1 Demand-Based Support

Tier 2 Personnel shall be trained to perform routine and preventive maintenance and to resolve warnings and alerts. They will receive clear instruction to escalate to Tier 3/4 support when proposed or demanded maintenance involves performing an activity which exceeds their training or which may impact service levels or violate protocol. Additionally, the Service Desk will receive the ticket and reach out and confirm (by voice) that the alert has been received and that the appropriate personnel have been dispatched.

Contractor shall use the severity levels below to properly respond to each item. The thresholds used to issue these tickets are based upon the SLA requirements of this CSOW:

<table>
<thead>
<tr>
<th>Priority Level</th>
<th>Help Desk Response</th>
<th>Resolution</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity 1 – Emergency</td>
<td>Call Response time (Trouble Ticket automatically generated)</td>
<td>Tier 2 support where possible, or escalate to Tier 3 or Tier 4.</td>
<td>Defects that cause the system to suspend, crash, or otherwise become completely inoperable; including errors that cause valid data to become corrupt in the database.</td>
</tr>
<tr>
<td>Severity 2 – Serious</td>
<td>Call Response time (Trouble Ticket automatically generated)</td>
<td>Tier 2 support where possible, or escalate to Tier 3 or Tier 4.</td>
<td>Defects that materially affect normal processing of work for which no reasonable work-around as determined by CCJPA is available.</td>
</tr>
<tr>
<td>Severity 3 – Inconvenient</td>
<td>Call Response time (Trouble Ticket automatically generated)</td>
<td>Tier 2 support with escalation as required.</td>
<td>Defects for which users have an acceptable, defined work-around that allows the system to continue work and where the error does not compromise data integrity or security.</td>
</tr>
<tr>
<td>Severity 4 – Minor</td>
<td>Call Response time (Trouble Ticket automatically generated)</td>
<td>Tier 2 support with escalation as required.</td>
<td>Defects where the system behavior does not exactly match the system specifications but does not significantly impact the processing of work or compromise data integrity or security.</td>
</tr>
</tbody>
</table>
6.7.4 Deliverables for Service Desk

The deliverable documents required for System Performance and Reliability Monitoring are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Desk Plan</td>
<td>Written set of Service Desk procedures and processes with escalation paths.</td>
</tr>
<tr>
<td>O&amp;M Database</td>
<td>Regular written reports on Solution performance and reliability containing</td>
</tr>
<tr>
<td></td>
<td>the elements defined in the approved SLA and indicators reported in</td>
</tr>
<tr>
<td></td>
<td>UAT testing results.</td>
</tr>
<tr>
<td>Monthly Service Desk report</td>
<td>Report with all service desk activity recorded including ticket lifecycle.</td>
</tr>
</tbody>
</table>

6.7.5 Spares Management

6.7.5.1 Spares Management when Supplying Materials as a Capital Sale

In the case of capital sale or transfer of ownership of the system hardware to CCJPA Contractor shall supply a Spares Management Plan that provides a mechanism to remove and replace defective hardware on-board trains and any physical data centers. Contractor shall store and have available sufficient quantities of components to support CCJPA’s deployed equipment. Contractor shall maintain the spares list and shall make it available to CCJPA on an as-needed basis. Contractor shall train CCJPA resources on the removal and installation of component spares. Contractor shall indicate if any spares or parts are reconditioned as well as the extent of the manufacturer’s warranty. Contractor shall provide insurance coverage of spares and verification of coverage for storage facilities. The quantity, distribution, and condition (new or refurbished) of spares are subject to CCJPA’s final acceptance.

Contractor shall be responsible for affixing CCJPA asset tags to all Solution equipment prior to assets going into a live production environment. Contractor shall be responsible for logging asset changes in the asset management system for tracking, audit, and depreciation purposes.

Contractor shall have sufficient inventory levels to support CCJPA’s contractual SLAs based on the following factors:

- CCJPA’s projected deployment schedule;
- Established and documented OEM mean time between failure (MTBF) rates;
- Actual failure rates for similar equipment;
- Expected hours of usage;
- Repair intervals;
- Shipping time to CCJPA;
- Other factors such as age of product, environmental conditions, and equipment anomalies;
- Staging plan for equipment refresh by region;
- Procedures for coordination between help desk and personnel responsible for component replacement;
- Procedures for determining the need for part replacement and how to replace the part.

Contractor shall be responsible for Spares Management and utilize its current process for management of inventory assets. Contractor shall provide for at least 5% of sparing of all equipment to support the O&M
of the Solution. All spares will be stored and managed by Contractor personnel. Contractor shall maintain a secure online system showing the spares inventory which will be available 24/7/365 for CCJPA and Contractor to access. Each spare will document at a minimum the following:

- Manufacturer;
- Model;
- MFR Part Number;
- ESN;
- IMEI (for cellular modems only);
- ICCID (for SIM cards)
- CCJPA asset tag number;
- Firmware Version (where applicable);
- Date Purchased;
- Warranty Date;
- Date Delivered;
- Received by.

6.7.5.2 Spares Management when Providing the Solution as a Service

Where Contractor is providing hardware on a service basis then CCJPA would still require that Contractor provides visibility into the spares management process used for each installed fleet in order to assess preparedness and understand any risks that may affect system availability.

6.7.6 Deliverables for Spares Management

The deliverable documents required for Spare Management are listed and defined as follows:

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spares Management Plan</td>
<td>Written set of Spares Management procedures and processes.</td>
</tr>
</tbody>
</table>

6.7.7 Asset Database & Configuration Management

Configuration Management will be a critical component of the Solution’s Asset Database. With potentially hundreds of assets in the field, process areas such as Warranty, RMA, Preventative Maintenance, Incident Management, and others rely on this system. Contractor shall be responsible for maintaining the Asset Database and use a Configuration Management Data Base (CMDB) to track Configuration Item (CIs) types and the assets associated with them. The CMDB will contain a record for every hard and soft CI associated with OBN physical components. Contractor shall capture and track attributes associated with each CI. These include but are not limited to:

<table>
<thead>
<tr>
<th>1. CCJPA Asset Tag Number</th>
<th>24. Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. CI ID</td>
<td>25. Contractor Part Number</td>
</tr>
<tr>
<td>3. CI Name</td>
<td>26. Number</td>
</tr>
<tr>
<td>4. CI Number</td>
<td>27. OEM Part Number</td>
</tr>
<tr>
<td>5. CI Type</td>
<td>28. Original Install Date</td>
</tr>
</tbody>
</table>
Additionally, Contractor shall track the upstream/downstream relationships associated with each CI. This is a critical component of assessing impacts of changes or incidents to other systems or users. Each CI will be assigned a status based on where it resides in the CI lifecycle. The following metrics shall be available in the CMDB:

- Ordered;
- Installed;
- Spare;
- Quarantined;
- RMA – Return Materials Authorization;
- BER – Beyond Economical Repair;
- DOA – Dead on Arrival;
- Active;
- Inactive.

Contractor shall provide a detailed description of proposed CI lifecycle management. CCJPA reserves the right to request that Contractor uses a Configuration Management system already in use by CCJPA. CCJPA also reserves the right to migrate Asset Database and Configuration Management services from Contractor responsibility to the CCJPA Wi-Fi Services responsibility with at least 60 days written notice.
7 Appendix A – Acronyms

AC Alternating Current
AP Access Point
API Application Program Interface
AREMA American Railway Engineering and Maintenance-of-Way Association
AWS Amazon Web Services
BOM Bill of Materials
CAB Change Advisory Board
CALEA Communications Assistance for Law Enforcement Act
CCJPA Capitol Corridor Joint Powers Authority
CMS Communications & Signals
CAT Category (i.e. CAT 6 Ethernet)
CI Configuration Item
CMDB Configuration Management Database
CMS Content Management System
CNA Captive Network Assistant
CoS Class of Service
COTS Commercial Off The Shelf
CPU Central Processing Unit
CSOW Conformed Statement of Work
DC Direct Current
DCS Data Communications System
DFS Dynamic Frequency Selection
DIL Digital Train Line
DRMT Division of Rail and Mass Transportation
EOL End of Life
FAI First Article Inspection
FAST Factory Acceptance Test
FCC Federal Communications Commission
FDR Final Design Review
FSE Field Service Engineering
FRA Federal Railroad Administration
FTP File Transfer Protocol
FY Financial Year
Gbps Gigabits per second
GHz Gigahertz
GP General Provision
GUI Graphic User Interface
HEP Head End Power
HSI PA High Speed Packet Access
HW Hardware
ICL Inter-Carriage Link
IDR Intermediate Design Review
IEEE Institute of Electrical and Electronics Engineers
IP Internet Protocol
IPR Interior Passenger Rail
KPI Key Performance Indicator
LAN Local Area Network
LAMP Linux, Apache, MySQL, PHP
LOS Local Distribution Site
LTE Long Term Evolution
MAC Media Access Control
Mbps Megabits per Second
MED Medium Earth Orbit
MIB Management Information Base
MIMO Multiple In Multiple Out
MPH Miles per Hour
MTTR Mean Time to Repair
MTBF Mean Time Before Failure
NIST National Institute of Standards and Technology
NOC Network Operations Center
NTP Network Time Protocol
PDR Preliminary Design Review
PCR Proof of Concept
PoE Power over Ethernet
PRR Passenger Rail Investment and Improvement Act
PTC Positive Train Control
OBIS On-Board Information System
ONB On-Board Network
O&M Operation and Maintenance
OSS Operation Support System
QC Quality Control
QoS Quality of Service
RF Radio Frequency
RFSQO Request for Statement of Qualifications
RTM Requirements Traceability Matrix
ROW Right Of Way
SAT System Acceptance Test
SIM Subscriber Identity Module
SLA Service Level Agreement
SNMP Simple Network Management Protocol
SDW Statement of Work
SRS System Requirement Specification
SSID Service Set Identifier
SSL Secure Sockets Layer
SSO Single Sign On
SW Software
TG Train To Ground
TCP Transmission Control Protocol
TR Technical Requirements
TSN Trackside Network
UAT User Acceptance Testing
UL Underwriters Laboratories
UPS Uninterruptible Power Supply
URL Uniform Resource Locator
VAC Volts (Alternating Current)
VDC Volts (Direct Current)
VHF Very High Frequency
VLAN Virtual Local Area Network
VPN Virtual Private Network
WAN Wide Area Network
WBS Work Breakdown Structure
WD Work Directive
WS Web Service