**Schedule 5(I)**

**Network Timing System (NTS)**

# California High-Speed Rail Authority

# Standard Specifications
## TSCC Specifications
## SPEC-0016 – Network Timing System (NTS)
## Rev. 0.0

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# Document Revision History – NTS Specifications

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# 1 INTRODUCTION

## 1.1 Scope of the Technical Specification

1.1.1 The scope of this Technical Specification is to define the Authority's Requirements for the Network Timing System (NTS), hereinafter: NTS.

1.1.2 This Technical Specification is based on the Authority's Design Criteria Manual (DCM) Chapter 12: Communication Systems and Train Control.

1.1.3 The functional architecture of the NTS is presented in Appendix A.

1.1.4 The requirements are formulated using the following words and their meanings:

- "Shall": Indicates a mandatory requirement that must be strictly implemented; a waiver from a mandatory requirement is permissible only with approval of a design variance.
- "Should": Indicates a preferred course of action; a design variance is not required if it is not exercised.
- "Must": Indicates an obligation or a mandatory requirement.
- "May": Indicates a permissible course of action within the limits of the standards; a design variance is not required if it is not exercised.

# 2 REFERENCE STANDARDS AND DOCUMENTS

## 2.1 General

2.1.1 The TSCC Contractor shall apply the in-force standards, guidelines, and specifications provided in this chapter for all stages of the design, test, manufacture, supply, delivery, assembly, installation, testing, commissioning, and training.

## 2.2 Design Guidelines

2.2.1 The latest version of the following Design Guidelines shall be applied:

| ID | Code | Title |
|---|---|---|
| [R1] | Design Criteria Manual | Chapter 12 – Communication Systems and Train Control |
| [R2] | AREMA Standards | Chapter 17 – High-Speed Rail Systems |

TABLE 33 DESIGN GUIDELINES

## 2.3 TSI

2.3.1 There are no applicable TSIs for the NTS.

## 2.4 Standards

2.4.1 The TSCC Contractor shall fully consider and apply the following standards, the in-force standards shall be applied.

| ID | Code | Title |
|---|---|---|
| [R1] | AES | Advanced Encryption Standard specification for the encryption of electronic data |
| [R2] | DIN 41091-1 | Dials for electric clocks; minute-stroke dials |
| [R3] | DIN 41091-4 | Dials for electric clocks; number dials |
| [R4] | EN 300 386 | Telecommunication network equipment; Electro Magnetic Compatibility (EMC) requirements; Harmonized Standard covering the essential requirements of the Directive 2014/30/EU |
| [R5] | EN 50112-1 | Railway applications - Fixed installations - Electrical safety, earthing and the return circuit -- Part 1: Protective provisions against electric shock |
| [R6] | EN 50112-2 | Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 2: Provisions against the effects of stray currents caused by d.c. traction systems |
| [R7] | EN 50121 | Railway Applications – Electromagnetic Compatibility |
| [R8] | EN 50121-3-2 | Railway applications - Electromagnetic compatibility - Part 3-2: Rolling stock - Apparatus |
| [R9] | EN 50121-4 | Railway applications - Electromagnetic compatibility - Part 4: Emission and immunity of the signaling and telecommunications apparatus |
| [R10] | EN 50125 | Railway applications - Environmental conditions for equipment |

| ID | Code | Title |
|---|---|---|
| [R11] | EN 50126-1 | Railway applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS Process |
| [R12] | EN 50126-2 | Railway applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety |
| [R13] | EN 50128 | Railway applications - Communication, signaling and processing systems - Software for railway control and protection systems |
| [R14] | EN 50159 | Railway applications - Communication, signaling and processing systems - Safety-related communication in transmission systems |
| [R15] | EN 55024 | Information technology equipment. Immunity characteristics. Limits and methods of measurement |
| [R16] | EN 60065 | Audio, video and similar electronic apparatus - Safety requirements |
| [R17] | EN 60297-3 | Mechanical structures for electronic equipment - Dimensions of mechanical structures of the 482,6 mm (19 in) series - Part 3-100: basic dimensions of front panels, sub racks, chassis, racks and cabinets |
| [R18] | EN 60529 | Degrees of protection provided by enclosures (IP Code) |
| [R19] | EN 60715 | Dimensions of low-voltage switchgear and control gear. Standardized mounting on rails for mechanical support of switchgear, control gear and accessories |
| [R20] | EN 61000-6 | Electromagnetic compatibility (EMC) - generic standards |
| [R21] | EN 61000-6-2 | Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments |
| [R22] | EN 61000-6-4 | Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments |
| [R23] | EN 61508 | Functional safety of electrical/electronic/programmable electronic safety-related systems |
| [R24] | EN 62305 | Protection against lightning |
| [R25] | IEC 60068-2-27 | Environmental testing Tests. Test Ea and guidance. Shock |
| [R26] | IEC 60068-2-6 | Environmental testing Tests. Test Fc. Vibration (sinusoidal) |
| [R27] | IEC 60068-2-75 | Environmental testing Tests. Test Eh: Hammer tests |
| [R28] | IEC 61000-3-6 | Electromagnetic compatibility (EMC) - Part 3: Limits - Section 6: Assessment of emission limits for distorting loads in MV and HV power systems - Basic EMC publication |
| [R29] | IEC 61000-3-7 | Electromagnetic compatibility (EMC) - Part 3-7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems |
| [R30] | IEC 61000-5-2 | Electromagnetic compatibility (EMC) - Part 5: Installation and mitigation guidelines - Section 2: Earthing and cabling |
| [R31] | IEC 61643 | Low-voltage surge protective devices |

| ID | Code | Title |
|---|---|---|
| [R32] | IEC 61850-9-3 | Communication networks and systems for power utility automation – Part 9-3: Precision time protocol profile for power utility automation |
| [R33] | IEC 62278 | Railway Applications Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) |
| [R34] | IEEE 1220 | IEEE Standard for Application and Management of the Systems Engineering Process |
| [R35] | IEEE 1588v2 | IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems |
| [R36] | IEEE 60068-2-1 | Environmental testing - Part 2-1: Tests - Test A: Cold |
| [R37] | IEEE 60068-2-30 | Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle) |
| [R38] | IPv4 and IPv6 | Dual stack |
| [R39] | ISO / IEC 18028-2 | Network security architecture for providing end-to-end network security Information Security Management System (ISMS). |
| [R40] | ISO 11064 | Ergonomic design of control centers |
| [R41] | ISO 15408 | International standard (Common Criteria) – Standard for computer security certification. |
| [R42] | ISO 7240-16:2007 | Fire detection and alarm systems — Part 16: Sound system control and indicating equipment |
| [R43] | ISO/CEI 15288 | Systems engineering - Systems life cycle processes |
| [R44] | ITU-T G.811 | Timing characteristics of primary reference clocks |
| [R45] | ITU-T G.8261 | Timing and synchronization aspects in packet networks |
| [R46] | ITU-T G.8262 | Timing characteristics of a synchronous equipment slave clock |
| [R47] | ITU-T G.8264 | Distribution of timing information through packet networks |
| [R48] | ITU-T G.8265.1 | Precision time protocol telecom profile for frequency synchronization |
| [R49] | ITU-T G.8271/Y.1366 | Time and phase synchronization aspects of telecommunication networks |
| [R50] | ITU-T G.8273.2/Y.1368.2 | Timing characteristics of telecom boundary clocks and telecom time slave clocks for use with full timing support from the network |
| [R51] | ITU-T G.8275 | Architecture and requirements for packet-based time and phase distribution |
| [R52] | NFPA 780 | Standard for the Installation of Lightning Protection Systems |
| [R53] | NIST SP 800-125 | Guide to Security for Full Virtualization Technologies. |
| [R54] | NIST SP 800-53 | Recommended Security Controls for Federal Information Systems and Organizations. |
| [R55] | NIST SP 800-82 | Guide to Industrial Control Systems (ICS) Security. |
| [R56] | RFC 1305 | Network Time Protocol (Version 3) Specification, Implementation and Analysis, |

| ID | Code | Title |
|---|---|---|
| [R57] | RFC 4330 | Simple Network Time Protocol (SNTP) |
| [R58] | RFC 7384 | Security Requirements of Time Protocols in Packet Switched Networks |
| [R59] | RFC 8633 | Network Time Protocol Best Current Practices |
| [R60] | SNMP | Simple Network Management Protocol |
| [R61] | SyncE | Synchronous Ethernet |
| [R62] | TIA / EIA 942-B | Telecommunications Infrastructure Standard for Data Centers |

**TABLE 34 LIST OF APPLICABLE STANDARDS**

## 2.5 UIC Recommendations

2.5.1 Not applicable to NTS.

## 2.6 Other Documents

2.6.1 The following documents shall be referred:

| ID | Document | Title |
|---|---|---|
| [R63] | Schedule 3 | Safety, Security and RAM Requirements |
| [R65] | Schedule 16 | Scope of Work |
| [R66] | Schedule 5(a) SPEC-0005 | Cybersecurity specification |

**TABLE 35 OTHER DOCUMENTS**

# 3 TERMS, DEFINITIONS, AND ABBREVIATIONS

## 3.1 General

3.1.1 All the terms, abbreviations, and definitions are provided in: Glossary of Terms, Abbreviations and Definitions.

# 4 SYSTEM DESCRIPTION

## 4.1 Purpose of the NTS

4.1.1 The purpose of the Network Timing System (NTS) shall be to distribute a centralized and accurate time reference to all the equipment for the California High-Speed Rail system.

## 4.2 System Definition

4.2.1 An NTS is a synchronized timekeeping infrastructure used to ensure precise and consistent time coordination across distributed devices, systems, or components within a network.

## 4.3 System Operational Context

4.3.1 The mission of the NTS is to provide a centralized and accurate time reference to all the equipment for California High-Speed Rail systems and to broadcast the time-of-day to passengers in compliance with operational needs.

## 4.4 Design Life

4.4.1 The design life shall meet the requirements as specified in the Scope of Work document.

4.4.2 The design life requirements of the NTS shall allow for the pertinent evolution and technological change of the NTS throughout its life.

4.4.3 The TSCC Contractor shall ensure that the NTS components with shorter design lifespans shall be managed by scheduled technology refresh strategies and spares management plans.

4.4.4 The TSCC Contractor shall ensure that the manufacturers will be able to produce NTS components (with equal or compatible technical specifications) for the entire design life required.

# 5 SYSTEM REQUIREMENTS

## 5.1 General Requirements

5.1.1 The NTS shall be designed in accordance with the requirements described in this specification.

5.1.2 A redundant NTS equipped with Global Navigation Satellite System (GNSS) receivers (primarily GPS) shall be designed and installed in the Operational Control Centre (OCC) and shall be used to synchronize all systems requiring time synchronization.

5.1.3 The TSCC Contractor's NTS design shall consider Master clocks provided in OCC and Sub-master clocks for each station, OCC, depot, other facilities, etc.

5.1.4 The TSCC Contractor's NTS design shall consider slave clocks (analog and digital) for time-of-day information to be installed at each station, OCC, depot, maintenance facilities, train care facilities, traction power, solar sites, and wayside facilities along the California high-speed line.

5.1.5 Analog and digital slave clocks in facilities (control and technical rooms, depots, stations, platforms, etc.) shall be provided by the TSCC Contractor and shall be synchronized via the NTS.

5.1.6 The TSCC Contractor's NTS design for clocks shall consider external constraints such as resistance to shock, vandalism, waterproofing, dust, reflections, etc.

5.1.7 The Network Timing System (NTS) shall transmit, in real time and via the Digital Communications Network (DCN), at a minimum, the following time data elements:

- Year
- Month
- Day
- Hour
- Minute
- Second

5.1.8 The TSCC Contractor shall ensure that the time displayed in the slave clocks is clearly and easily visible from any point of the public area (platforms, waiting area, etc.); the quantity and location of clocks shall be agreed with the Authority.

5.1.9 When an accurate time must be displayed, digital slave clocks shall be designed and installed, for instance, at OCC, Technical Rooms, Station Control Rooms, offices, etc.

5.1.10 Upon approval by the Authority and according to architectural and design criteria, some of the digital clocks may be embedded in the Customer Information Displays (CIS).

5.1.11 The use of analogue slave clocks makes it possible to increase the consultation distance of the time, and they shall be installed in the station entrance, hall, or concourse of each station, on platforms, in the large halls of the depot areas, or in the storage/shunting area. The offices of each station shall also be equipped with analogue slave clocks.

5.1.12 NTS shall be designed considering that the length of passenger platforms for stations is 400m, and in compliance with the station designs.

5.1.13 NTS clock design shall be compatible with California HSR branding, visual identity, signage system, and graphical charts, and be fully integrated in the overall station designs and shall take architectural constraints into account.

5.1.14 The TSCC Contractor's NTS design shall respect and adapt to the architectural designs of stations and other facilities to avoid impacts on the constructive elements of the different facilities and shall fit and be installed harmoniously.

5.1.15 Only technology systems with service-proven records for application on railway infrastructure shall be proposed by the TSCC Contractor.

5.1.16 NTS equipment shall be placed in locations where it does not infringe on the passage of people.

## 5.2 Environmental Conditions Requirements

5.2.1 The TSCC Contractor's NTS design shall respect local climatic conditions.

5.2.2 All equipment shall be protected from damage or degradation in performance due to shock or vibration as experienced in the railway environment.

5.2.3 The TSCC Contractor's design for the NTS shall comply with the following telecom-related environmental requirements (list non-exhaustive):

- The equipment provided and installation-related material shall be adapted to the special local environmental conditions, e.g., stainless-steel fixations, housings, etc.
- Based on the different installation sites, different ingress protection (IP) requirements shall be specified.

5.2.4 Outdoor NTS elements shall be resistant to high temperatures and de-icing agents.

## 5.3 Operational Requirements

5.3.1 The TSCC Contractor's NTS design shall ensure compliance with the California HSR operational rules and Operational Concept when (at least):

- Defining the locations required for the placement of the displays for the analog and digital clocks for time of the day information.

5.3.2 The TSCC Contractor's NTS design shall allow the operation and maintenance of the main line and related local facilities as per Operational Concept.

## 5.4 Functional Requirements

5.4.1 A Network Time Server natively supporting IEEE 1588v2 Precision Time Protocol - PTP Master clock shall be installed in the technical room of the OCC. It shall be synchronized by a GNSS system (primarily GPS) via antennas ideally installed on the roof of the building (depending on the reception level).

5.4.2 All OCC equipment shall be synchronized by the OCC Master clocks.

5.4.3 The Master clocks, placed at the OCC, shall be interlinked to achieve full redundancy. Furthermore, in case of failure of the GNSS link of the Master clock, the other Master clock shall provide the time information received from its GNSS to this Master clock through the redundant path.

5.4.4 The NTS shall allow to handle leap seconds to ensure accurate and synchronized timekeeping (at least):

5.4.5 Leap second insertion and notification: The NTS shall have the capability to insert a leap second when required by international timekeeping authorities (e.g., International Earth Rotation and Reference Systems Service, IERS) and shall be able to receive and process leap second announcements and notifications from authoritative sources like the IERS or relevant national agencies. NTS shall be capable of automatically adjusting the time accordingly when a leap second is announced.

5.4.6 Traceability and record-keeping: The NTS shall maintain records of leap second events, including the date and time of insertion and any associated adjustments to the system's timekeeping, and shall ensure that historical data on leap seconds is available for reference and auditing purposes.

5.4.7 The NTS receives time-of-day (ToD) source from the GNSS. In the absence of a valid GNSS signal, the Master clock shall operate in free-running mode with the internal clock supplying the time signal. On restoration of the GNSS signal, the receiver shall validate the GNSS signal automatically without any manual intervention. After successful validation, the Master clock shall self-correct, if necessary.

5.4.8 In each station or facility, a Sub-Master clock shall be installed. It shall be synchronized with the OCC Master clocks and shall ensure the synchronization of all local equipment.

5.4.9 In the absence of a valid Master clock signal, the Sub-Master clocks shall operate in free-running mode with an internal clock supplying the time signals. On restoration of the Master clock signal, the Sub-Master clocks shall validate the signal. After the successful validation, the Sub-Master clocks shall self-correct, if necessary.

5.4.10 In the absence of a valid Sub-Master clock signal, the slave clocks for time-of-day information shall synchronize via the Sub-Master clock of an adjacent station or facility or operate in free-running mode with an internal clock supplying the time signals. On restoration of the Sub-Master clock signal, the slave clocks shall validate the signal. After the successful validation, the slave clocks shall self-correct, if necessary.

5.4.11 The TSCC Contractor’s design for NTS shall be compliant with ITU-T G.811: Timing characteristics of primary reference clocks.

5.4.12 The NTS shall be designed to provide synchronized time information within the DCN.

5.4.13 The synchronized time information shall be provided to clients as clocks, network devices, servers and end applications using IEEE 1588v2 Precision Time Protocol (PTP) and additional protocols and standards, such as G.8271, G.8275.1&2, G.8273.1&2, SyncE and others, to improve the overall performance of the Network Timing System to achieve the level of accuracy required by the different systems to be synchronized (e.g. FRMCS).

5.4.14 The protocols shall incorporate algorithms to compensate for delays in the transmission network, like Best Master Clock Algorithm (BMCA) and/or others.

5.4.15 The TSCC Contractor’s design for NTS shall include a comprehensive Network Management System (NMS) for the entire network’s components and devices. The synchronization and time broadcasting system will be interfaced with the NMS to ensure the reporting, alarms, defects, status, and other relevant information of Master clocks, Sub-Master clocks, and slave clocks, preferably via SNMP v3 (any other standard protocol shall be subject to approval).

5.4.16 The TSCC Contractor’s NTS design shall support and detail normal and degraded modes of the synchronization system.

5.4.17 Switching from the Main Master clock to the Backup Master clock shall be automatic and transparent for synchronized systems.

5.4.18 Clocks for time information shall be visible in all lighting conditions and have their own lighting source if necessary.

5.4.19 Location of clocks shall consider the installation of other equipment like cameras, information displays, fixed signage, loudspeakers, etc.

5.4.20 Clocks installed in public areas shall be sized, designed, and installed such that they can be read from any position easily.

5.4.21 For passenger information clocks (digital and analog slave clocks), networked IP-based clocks with PoE-type power supply should be adopted, as soon as transmission distances allow it (typically less than 100m), i.e., in the presence of nearby network switches and according to the consumption of the clocks. For longer distances, other technologies such as Powered Fiber Cable systems may be used to avoid extra power feeding cables and devices.

5.4.22 The NTS shall deliver the time and date in a Coordinated Universal Time (UTC) format.

5.4.23 Applications which require to timestamp log entries, alarms, events etc., shall use Pacific Standard Time (PST) expressed in the 24-hour format: HH:MM: SS, to an accuracy of one hundredth of a second.

5.4.24 Clocks, displaying the common time reference, shall be configurable to display UTC, PST, or Pacific Daylight Time (PDT) in 12- or 24-hour format.

5.4.25 Customer facing and operator time displays shall be shown in Pacific Standard and Pacific Daylight time as defined for the United States.

5.4.26 The NTS equipment shall be remotely manageable.

5.4.27 The NTS shall send alarms to appropriate personnel.

5.4.28 Maintenance alarms shall include intermittent and hard failures for delivering the NTS signal.

## 5.5 Performance Requirements

### 5.5.1 Master Clock System

5.5.1.1 The suggested architecture for the NTS shall be based on a standard hierarchy model (master-slave). The higher the timing equipment is in the hierarchy, the more precise the timing source shall be.

5.5.1.2 The Master clock gets the time reference from a GPS satellite signal, which is generated by an atomic clock.

5.5.1.3 The Master clock equipment shall have an internal atomic oscillator in the event of a loss of GNSS signals. The oscillator shall be able to provide a holdover value in the range of +/- 1 µs/day (after 30 days of synchronization).

5.5.1.4 At each station, a Sub-Master clock shall be located to provide local timing to local subsystems. The Sub-Master clock shall get its time source from the Master clock. This architecture guarantees a local timing source in the event of a failure of the DCN or the Master clock.

5.5.1.5 The Sub-Master clock and slave clocks shall have internal battery backup of at least 12 hours.

5.5.1.6 For time servers, every Ethernet and optical port shall be completely independent with its own MAC address, allowing the synchronization of several networks. These ports shall be isolated with no communication and interconnections between them (galvanic separation or any other technique).

5.5.1.7 At least the following reference sources shall be selectable to synchronize the system: GPS, PTP/IEEE1588v2, NTP, SyncE.

5.5.1.8 A PTP profile is a selection of optional features and attribute values. The purpose of a profile is to set restrictions on the possible PTP attributes to simplify the interoperability between different PTP devices in a certain application. At least the following PTP Profiles shall be supported:

- IEEE 1588v2 (PTPv2)

- IEC 61850-9-3
- ITU-T G.8265.1 Frequency
- ITU-T G.8275.1 Phase/Time
- ITU-T G.8275.2 Phase/Time

5.5.1.9 Time server shall support, at least, 100/1000BaseT/TX/FX Ethernet and optical networks.

5.5.1.10 The TSCC Contractor's NTS design shall support, at least, the following network services: PTP, NTP, SNTP, Syslog, SNMP v3 and MIB, SSL, DHCP, IPv4/IPv6.

5.5.1.11 The GNSS Receiver/Decoder Unit, located adjacent to the antenna, shall continuously collect the external time information for the NTS.

### 5.5.2 Digital Clock Displays

5.5.2.1 The TSCC Contractor's design of the single-sided digital slave clocks shall be of high quality and blend into the architecture of the area in which they shall be located.

5.5.2.2 All digital slave clocks shall be programmable both for 12 hour and 24-hour display and shall display four digits time in HH:MM format. The default configuration shall present the time information in the 24h format.

5.5.2.3 The TSCC Contractor may propose to display alternative additional strings, such as, for example, date in MM/DD format and temperature, with an adjustable period of display. The digital clock may then be configured in such a way that it shall display Date, Temperature, or Time, alternatively, as per the Authority's requirement.

5.5.2.4 Sufficient digital slave clocks shall be provided to enable a clear view of the time from any location within the facilities (OCC, control and technical rooms, depots, offices, etc.).

5.5.2.5 The character height of the display shall not be less than 5 cm, for a minimum readability distance of 20 meters, and shall allow a viewing angle of at least 120° with perfect visibility, whatever the lighting conditions.

5.5.2.6 Digital Clock Displays' (DCD) front face shall be glare resistant at all ambient lighting conditions.

5.5.2.7 In case of Master Clock loss, the display shall provide a minimum accuracy of 1 second.

5.5.2.8 Accuracy shall be better than ± 0.1 second/24 hour when synchronized and ± 1 second/ 24 hour when in free-run mode (loss of signal).

5.5.2.9 An LED status indicator on the face of the clock may illuminate when the clock is not synchronized.

### 5.5.3 Analog Clock Displays

5.5.3.1 The TSCC Contractor's design of the analog slave clocks shall be of high quality and blend into the architecture of the area in which they will be located.

5.5.3.2 The shape of the analog clocks shall be round, and the diameter shall be not less than 30 cm.

5.5.3.3 Sufficient analog slave clocks shall be provided to enable that the indicated time is clearly and easily readable from at least 20m from the location of the clock within their respective areas.

5.5.3.4 The face of the clock shall be off-white; the time marks on the face shall be black, visible in all lighting conditions.

5.5.3.5 The hour markings shall be in an English numeral format and in an easily read font. Minute / second display shall be provided. The analog clock shall have black hour and minute hands and a red second-hand indicator.

5.5.3.6 The analog clocks shall contain a stepper motor drive and state-of-the-art microprocessor and electronics control to rapidly synchronize the hands on the face of the clock to an accurate reference.

5.5.3.7 The stepper motor drive and gear system shall be of all metal construction for long, maintenance-free life and high product reliability. The gear and drive train system shall be smooth and quiet in operation to minimize motor noise.

5.5.3.8 The analog clocks shall be available with the following options: LED illumination, double-face ceiling or wall mount, stainless steel enclosure.

5.5.3.9 A hand positioning sensor should be used to automatically detect and correct the clock's hand positions, thus eliminating manual time adjustments.

5.5.3.10 The analog clocks shall be provided with a mandatory feature to configure the turn-on/turn-off of illumination at selected hours.

5.5.3.11 The analog clocks shall incorporate a holdover function for the first 24 hours and then stop at the 12 o'clock position to indicate a loss of signal and an unsynchronized state.

5.5.3.12 Subject to the architectural constraints for each specific location, the clocks shall either be wall mounted, ceiling mounted, or pole mounted. The TSCC Contractor shall determine the mounting method and shall submit it to the Authority for review before installation.

### 5.5.4 Network Management System

5.5.4.1 The status of the NTS, including GNSS Receiving System, Master clock Units, Clock Distribution System, PTP Servers, Sub-Master clocks and Slave Clocks shall be monitored using SNMP v3 (or better solution) by the proposed dedicated Network Management System (NMS) to be provided at OCC.

5.5.4.2 The NMS shall provide full configuration support for Master clock Units, Sub-Master clocks, and slave clocks.

5.5.4.3 All server functions and configuration shall be accessible via front panel keypad and by remote management client to support status monitoring, alarm messages (polling or event driven), Built-In-Test functions, configuration, etc.

5.5.4.4 Status and diagnostics shall be reported via SNMP v3 (or another standard protocol) to each Management System regarding (not limited to):

- Power supply failure.
- Loss of GNSS synchronizing time signal.
- NTS failover.
- Unauthorized login attempts.
- Data security: penetration, jamming, spoofing, hacking, or clock manipulation attempts.

5.5.4.5 The NTS Server shall retain local logs stored in non-volatile flash memory and be remotely accessible.

### 5.5.5 Safety Requirements

5.5.5.1 NTS shall comply with the safety requirements defined in Schedule 1.

### 5.5.6 RAM Requirements

5.5.6.1 The TSCC Contractor shall be responsible for performing all the activities as specified in Schedule 1 and the Authority's RAM Management Plan.

## 5.6 Cybersecurity and Security Requirements

5.6.1 The TSCC Contractor's NTS design shall be in full compliance with California HSR cybersecurity policies.

5.6.2 The TSCC Contractor's NTS design shall be compliant with best practices specified in RFC 8633 for general network security, time protocol-specific security, and PTP and NTP server and client configuration and the security aspects of the security aspects of time distribution protocols in packet networks discussed in RFC 7384 which focuses on the two most common protocols the Network Time Protocol (NTP) and the Precision Time Protocol (IEEE1588/PTP).

5.6.3 Hostile cyber operations, such as jamming and spoofing of GNSS signals, are a growing concern. The NTS GNSS server/receiver shall include security mechanisms to prevent GNSS denial and disruption in full compliance with the California HSR cybersecurity policies.

# 6 INTERFACES REQUIREMENTS

## 6.1 General Requirements

6.1.1 The interfaces are classified as following:

- Third Party interfaces: interfaces between TSCC systems and systems provided by Third Party (excluding CHSR contractors)
- External interfaces: interface between TSCC systems and systems provided by CHSR contractors (Civils Packages, Stations contractor, Facilities contractor, Solar PV and BESS contractors)
- Internal Interfaces: Interfaces between systems within the TSCC scope

6.1.2 The TSCC Contractor shall develop design considering the identified Third Parties, External and Internal interfaces to ensure the required functionalities and performance described in this specification.

6.1.3 The TSCC Contractor shall, if necessary, propose any additional interfaces required to ensure the functionalities and performance described in this specification.

## 6.2 External Interfaces – station contractor

6.2.1 The NTS shall have a redundant interface with the following systems to provide a centralized and accurate time reference and synchronization to all the equipment:

- Heating Ventilation and Air Conditioning
- ETCS system
- Escalators
- Elevators
- Fire Protection Systems
- Station Digital Clocks
- Hydraulic Systems
- Lighting Systems
- LV Power Systems

## 6.3 External Interfaces – facilities contractor

6.3.1 The NTS shall have a redundant interface with the following systems to provide a centralized and accurate time reference and synchronization to all the equipment:

- Heating Ventilation and Air Conditioning
- ETCS system
- Elevators
- Fire Protection Systems
- Station Digital Clocks
- Hydraulic Systems
- Lighting Systems
- LV Power Systems

6.3.2 The TSCC Contractor shall install all NTS core network equipment in the OCC being provided by the facilities contractor.

6.3.3 The TSCC Contractor shall provide the facilities contractor the following requirements::

- Equipment dimensions

- Equipment clearances requirements
- Equipment mounting and fixings requirements
- Cable routes/containment requirements
- Equipment loadings
- Installation and maintenance requirements
- Equipment heating loads
- Equipment cooling loads
- Equipment hydraulic requirements

6.3.4 To be provided by facilities contractor to accommodate the TCSS equipment installation and operational/maintenance requirements:

- Room dimensions and layouts
- Room facilities (Plumbing, HVAC, Lighting, Fire Protection Systems, Doors, electricity)
- Room raised floor system
- Delivery access routes.
- Maintenance access routes

## 6.4 Internal Interface for NTS

### 6.4.1 Interface with the Digital Communication Network

6.4.1.1 The NTS shall have redundant interfaces with the DCN for the transport of NTS signals and data in a secure and reliable way, and the interconnection of all NTS devices along the project.

### 6.4.2 Time distribution to TSCC systems

6.4.2.1 The NTS shall have a redundant interface with the following systems to provide a centralized and accurate time reference and synchronization to all the equipment:

- Digital Communications Network
- ETCS system
- Traffic Management System
- Interlocking
- Power SCADA System
- Traction Power Systems
- Wireless Communication Systems
- Integrated Control and Supervision System
- Low Voltage Power System
- Medium Voltage Power System
- CCTV system
- Public Address and Customer Information System
- Telephony system
- Fire Protection System
- Electronic Access Control System
- Asset Protection System.
- Maintenance Management system.
- MEP system.

### 6.4.3 Interface with Integrated Control and Supervision System

6.4.3.1 The TSCC Contractor shall ensure that the NTS NMS is integrated with the Integrated Control and Supervision System (ICSS). The NMS shall expose required interfaces, alarms, status indicators, and performance metrics using standard protocols (e.g., SNMP, RESTful APIs, or as defined by the ICSS integration specifications) to support centralized fault, performance, and configuration monitoring across subsystems.

### 6.4.4 Interface with Enterprise Asset Management Systems (EAMS)

6.4.4.1 The NTS shall provide static Asset Information and dynamic Asset Information to the EAMS for maintenance activities and asset lifecycle management activities.

### 6.4.5 Interface with Low Voltage Power System

6.4.5.1 The NTS shall interface with an Uninterruptible Power Supply (UPS) to get the required power to feed the Telephony System equipment.

# 7 MATERIALS, PRODUCT AND COMPONENTS REQUIREMENTS

## 7.1 General Requirements

7.1.1 All materials supplied by the TSCC Contractor shall conform to the requirements and test methods of the relevant EN standards or other applicable recognized standards. Refer to 2.4.

7.1.2 All materials supplied shall be of sufficient grade and quality to meet the design life requirements.

## 7.2 Software and Hardware Requirements

7.2.1 The NTS Servers shall support security hardening and authentication protocols such as RADIUS, TACACS, X.509 Certificate Authority, and LDAP, etc.

7.2.2 OCXO or rubidium local oscillator and minimum Coarse/Acquisition (C/A) code 24 channels GNSS receiver.

7.2.3 The network equipment carrying synchronization information shall be compliant with (not limited to) IEEE 1588v2 Precision Time Protocol (PTP), G.8271, G.8275.1&2, G.8273.1&2 to provide a time accuracy, expressed in terms of time error with respect to a common reference, in the range of ~1 µs, taking into special consideration the accuracy requirements of the communications network.

7.2.4 Time synchronization shall be distributed via timing protocols such as IEEE 1588v2 PTP, G.8271, G.8275.1&2, G.8273.1&2, and others which define how the time and phase synchronization references are transported over the network. The timing support in the intermediate nodes (e.g., Ethernet switches and/or routers) concerns specific hardware as well as software timing functions.

7.2.5 In the case of PTP, these functions may correspond either to the telecom boundary clock (T-BC) or to the telecom transparent clock (T-TC), with hardware timestamping at the related interfaces.

7.2.6 The NTS shall be mainly comprised of the following elements (not limited to):

- Redundant centralized Master clock located in the OCC.
- Sub-Master clock installed at each station.
- Slave clocks installed throughout selected areas within the Stations, Depot, OCC, wayside facilities.
- An NMS deployed on server-grade hardware and accessed from dedicated workstations located in the OCC.

7.2.7 The NTS shall provide appropriate clock output interfaces, timing, and reference distribution.

7.2.8 The type, quantity, and capacity of the Master clocks and Sub-Master clocks outputs shall be determined and dimensioned according to the requirements of the various systems in the project.

7.2.9 The NTS shall use GNSS Antennas with mounting hardware, which shall be positioned in an unobstructed area to provide a clear line of sight to no fewer than four of the orbiting satellites at all times and the antenna positions will free from potential obstructions due to future tree growth and surrounding urban development.

7.2.10 The GNSS Antennas installation shall include lightning protection.

7.2.11 The delivered NTS shall allow synchronization and support future additional expansion of 20% regarding:

- System clients.

7.2.12 Systems applications.

- Servers and PCs.
- Databases.

- Field end-devices.
- Users and/or workstations.

7.2.13 Expansion and scalability shall not impose and/or degrade the NTS performance, latency, or response times.

7.2.14 The NTS central system shall be designed without a single point of failure.

7.2.15 The NTS shall be designed with equipment and circuit redundancy such that a single failure (e.g., electronic card) does not affect the NTS service. In other words, internal redundancy is required for all equipment composing the NTS.

7.2.16 The Master clock and backup Master clock components shall be functionally redundant to ensure that Network Synchronization and Time Distribution services remain operational during any single hardware, cabling, or software failure.

7.2.17 The NTS Central Servers shall have redundant architecture and connectivity, including hardware, software, network, power supply, cabling, cooling, data backup, disaster recovery planning, and physical security, so that NTS survives during any failure of the aforementioned items.

7.2.18 A fault-tolerant design with protection against failure shall be provided to achieve system availability. Protections shall include, but not be limited to, path diversity, redundancy, and duplication of reliability-critical equipment, components, and circuits.

7.2.19 Low toxicity, low smoke emission, low flammability, zero halogen fire retardant cable shall be used for the distribution of NTS signals.

## 7.3 EMC Requirements

7.3.1 The NTS shall be fully immune and protected from any Electromagnetic Interference (EMI) with the traction power, multi-tubular cabling, and Radio Frequency Interference (RFI). The EMI emissions shall be mitigated in accordance with applicable standards (EN 50122 or equivalent)

# 8 TOLERANCES

8.1.1 Not applicable to NTS.

# 9 SCOPE OF SUPPLY AND DELIVERY

## 9.1 General Requirements

9.1.1 The TSCC Contractor shall supply and deliver all components related to the NTS System.

## 9.2 Specific Requirements

9.2.1 The NTS scope of supply and delivery shall include (not limited to):

- Master clocks.
- Sub Master-clocks.
- GNSS antennas.
- Workstations/HMIs.
- Digital clocks.
- Analog clocks.
- Cabling and connectors.
- Racks.
- Software architecture, including full definition of all protocols used.
- Management System.
- SW licenses.
- Auxiliary elements, tools, and gear (lightning protectors, attachments, bindings, testing equipment, etc.).
- Spare parts.

# 10 MANUFACTURING

## 10.1 General Requirements

10.1.1 General manufacturing requirements are defined in the Scope of Work.

# 11 INSTALLATION AND INTEGRATION

## 11.1 General Requirements

11.1.1 General installation and integration requirements are defined in the Scope of Work and Schedule 3.

# 12 TESTING & ACCEPTANCE

## 12.1 General Requirements

12.1.1 General testing and acceptance requirements are defined in the Scope of Work and Schedule 3.

# 13 SUBMITTALS

## 13.1 General Requirements

13.1.1 General submittal requirements are defined in the Scope of Work.

# 14 QUALITY MANAGEMENT

## 14.1 General Requirements

14.1.1 General quality management requirements are defined in the Agreement and associated Schedules.

# 15 ADDITIONAL INFORMATION REQUESTED

## 15.1 General Requirements

15.1.1 In addition to the mandatory requirements outlined in this specification, the Authority reserves the right to request from the TSCC Contractor and Supplier information pertaining to the performance of proposed or supplied elements under similar service conditions, with particular emphasis on railway management aspects which may influence NTS subsystem reliability, availability, and maintainability characteristics.

# 16 LOGISTICS

## 16.1 General Requirements

16.1.1 General logistics requirements are defined in the Agreement.