Government of South Australia
Department for Infrastructure and Transport

Traction Power SCADA Functional and Performance Specification – Tram System

SAPTA Asset Management

CE2-DOC-003522

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1. Introduction

The South Australian Public Transport Authority (SAPTA) is a Directorate within the Department for Infrastructure and Transport (DIT) responsible for the delivery of public transport services.

SAPTA on behalf of the Department manages the Adelaide Metropolitan Public Transport Network. As part of the execution of responsibilities of this role it must have a governance structure which includes the adoption of standards, policies and procedures.

The Adelaide Tram Network (ATN) comprises the Glenelg, Hindmarsh, Botanic and Festival Plaza tram lines. The ATN includes a diverse range of public transport assets including track, signals, communications, tram stops, traction systems, overhead wire, Electrical Engineering and rolling stock. The Tram Network is operated and maintained by an outsourced service provider: Torrens Connect.

This specification stipulates the minimum performance and functional requirements for traction power Supervisory Control and Data Acquisition (SCADA) system works required to remotely monitor and control the electrified portions of the tram network.

2. Purpose

This specification forms part of the engineering management system (EMS) and is intended toensure that the traction power SCADA system (TRAM SCADA SYSTEM) serving the Adelaide Metropolitan tram network is not subject to any risks not deemed to meet the So Far As Is Reasonably Practicable (SFAIRP) principles under Rail Safety National Law (RSNL).

3. Scope

This specification must be applied to the design, procurement, construction, installation, testing and commissioning of all new traction power SCADA systems works to serve the ATN.

The intended audience for this specification includes:

- ATN Maintenance functional areas,
- ATN Operations functional areas,
- The Department Rail Projects divisions; and
- The Department contractors to the extent specified in their contract.

The SCADA system must be of highest reliability and based on the state-of-the art technology. It must be capable of monitoring and controlling traction power supply from a remote location (control center). The system should be capable of collecting, storing, displaying, and analyzing data as stipulated in the specification.

Interpretation of any technical meanings of the specifications and sorting out technical disputes regarding this specification must be decided by the SAPTA system engineer electrical lead, whose decision must be final and binding.

The tenderers/project proponents must familiarize themselves with site conditions before quoting against tenders based on this specification. Conditions particular to individual sites, including availability of communication and spare channels, conditions & space at the control center, switching posts, proximity to Road/Rail, sequence in which RTUs sites will be offered by railways for taking up work, and any special conditions concerning erection and commissioning of SCADA system must be clarified in a pre-bid meeting to be arranged by the purchaser with the tenderers.

4. Related Documents

DOCUMENT NAME	DOCUMENT NUMBER
Traction Power Network tram system	TP2-DOC-003521
Traction DC Substation Design and Construction – Tram System	TP2-DOC-003520
Tram SCADA standard	CE2-DOC-003522
Communications Network Principles and Practices for Public Transport - Engineering Standard	PTS-AR-10-CN-SPE-00200400
Guideline for Low Voltage Electrical Earthing and Bonding for the Adelaide Metro Tram Network	TP2-DOC-002020
Torrens Connect MOC	[SQE-FRM-NIL-0006]
Pit and Conduit Standard for Signalling and Communication Cables	PTS-MS-10-SG-STD-00000094
Standard Drawing - Tram Network - Electrical System Over viewing - Single line diagram	TP2-DRG-006980
Development and Approval of Engineering Waivers	PR-AM-GE-807

5. References

- Acts and Regulations
- Rail Safety National Law (South Australia) Act 2012
- SA Workplace Health and Safety Regulations
- South Australian Electricity Act 1966
- AS 1000 - International system of units (SI) and its application.
- AS 2067 - Substations and high voltage installations exceeding 1 kV ac
- AS 3100 - Approval and Test Specification – General Requirements for Electrical Equipment
- AS 3111 - Approval and test certification – miniature over-current Circuit Breakers
- AS 4292.4 - Railway safety management - Signalling and telecommunications systems and equipment
- AS 4312 - Atmospheric corrosivity zones in Australia
- AS 60068 (set) - Environmental Testing
- AS 60529 - Degrees of protection provided by enclosures (IP Code)
- AS 60870 (set) - Telecontrol equipment and systems
- AS 60947.2 – Low voltage switchgear and control gear – Part 2: Circuit breakers
- AS 60950.1 – Information technology equipment – Safety –General requirements
- AS 61131 (set) - Programmable Controllers
- AS 61508 (set) - Functional safety of electrical/electronic/programmable electronic safety- related systems
- AS/CA S008 - Requirements for customer cabling products
- AS/CA S009 - Installation requirements for customer cabling (Wiring Rules)
- AS/NZS 11801.1 - Information technology—Generic cabling for customer premises, Part 1: General requirements
- AS 11801.3 - Information technology - Generic cabling for customer premises, Part 3: Industrial premises
- AS 11801.5 - Information technology - Generic cabling for customer premises, Part 5: Data centres
- AS/NZS 1768 - Lightning protection
- AS/NZS 2312 - Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
- AS/NZS 3000 - Electrical installations (the Australian/New Zealand Wiring Rules)
- AS/NZS 3008.1.1 – Electrical installations – Selection of cables – Part 1.1: cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions.
- AS/NZS 3013 - Electrical installations – Classification of the fire and mechanical performance of wiring systems AS/NZS 61000.6.2 -Electromagnetic Compatibility (EMC) - Part 6.2: General standards - Immunity for industrial environments
- AS/NZS 61000.6.3 -electromagnetic Compatibility (EMC) - Part 6.3: Generic standards – Emission standard for residential, commercial, and light-industrial environments
- Telecommunications Technical Standard (Surge Protective Devices for Telecommunication Applications – AS/NZS 4117) 2015

- EN 50121 (set) - Railway Electromagnetic Compatibility
- EN 50126 (set) - Railway applications - The specification and demonstration of reliability, availability, maintainability, and safety (RAMS)
- EN 50128 - Railway applications. Communications, signalling and processing systems. Software for railway control and protection systems.
- EN 50159-1 - Safety related Communication in Closed Transmission Systems.
- EN 50159-2 - Safety related Communication in Open Transmission Systems.
- IEC 60870-5-104 - Telecontrol protocol
- IEC 61850 (set) - Substation Automation
- IEEE 1008 - Software unit testing
- IEEE 1012 - Software verification and validation plans
- IEEE 1059 - Guide for software verification and validation plans
- IEEE 802.3 - Telecommunications and information exchange between systems – Local and metropolitan area networks
- IEEE 829 - Software test documentation
- ISA 99.00.01 - Security for Industrial Automation & Control Systems
- ISA-18.2 - Management of Alarm Systems for the Process Industries
- AS/NZS ISO/IEC 27002 - Information technology – Security techniques – Code of practice for information security management

6. Overview – Existing and Future Configuration

6.1. Overview – Existing Tram SCADA Configuration

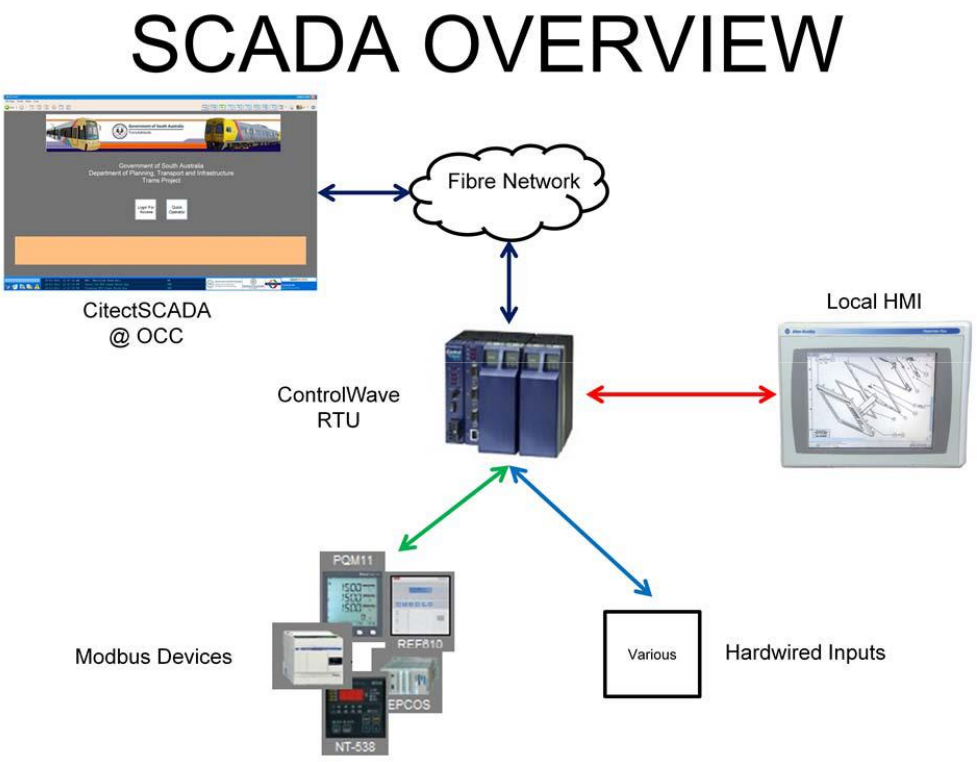
The existing Tram SCADA System is configured to allow a duty Electrical Control Operator / Tram controller to remotely monitor & control the switching stationsserving the electrified sections of the ATN via remote terminal units (RTU's).

The ATN Tram SCADA is arranged in two levels, as follows:

- **Master Station Level**, where the Operator remotely monitors and controls system-wide equipment from a duty Workstation via redundant SCADA Servers located at the Glengowrie Tram depot.
- **Switching Station Level**, where HMIs located at each converter Station, provide interfaces to the field equipment that is monitored and controlled at these sites.

Communication within and between the master stations and switching stations is viadual Ethernet data links over the fibre network, as depicted below:

Figure 1 - Overview - Configuration of existing ATN traction power SCADA system



7. Traction Power SCADA Functions

7.1. Primary Function

Traction power SCADA systems provide the means for a skilled operator to remotely monitor and control traction power networks from a computer-based workstation located at a master station within the operational control centre.

7.2. Operator Functions

The ATN Tram SCADA System must provide the duty operator the capability to:

- Command the real-time switching of remote power supply and feeding arrangements at outstations where the controlled switchgear is motorised by design.
- Monitor the real-time operating state and functional status of all remote electrical switchgear, traction power equipment and associated auxiliary equipment at outstations.
- In real-time, remotely monitor:
  - The secure state of the outstations, and
  - The electrical supply characteristics (voltage, current, power quality) and energy consumed on the supply and feeding arrangements at switching stations, and
  - Provide time synchronization between the master station and outstations and associated time tagging of systemic information.

7.3. Process Functions

The ATN Tram SCADA System must provide the duty operator and the SCADA Engineer:

- An optimal human machine interface (HMI) for efficient system operation.
- Optimal information logging and reporting tools to aid decision-making.
- Reliable data storage and tools for detailed analysis of archived historical events.
- Tools to manage and modify the Tram SCADA System configuration.

7.4. Support Functions

The above ATN Tram SCADA System primary functions are dependent on hardware and software systems that must provide:

- A set of real-time services providing the following support functions:
  - Data acquisition: to acquire any digital or analogue information from the field equipment through RTUs.
  - Control processing: to send commands to field equipment through RTUs.
  - Alarms and events management: to generate, display and sort events, prioritise, and escalate specific events as alarms, process alarm acknowledgement and manage avalanche data flow events.
  - Archiving: to store data and events in an historical database and allow subsequent retrieval for analysis.
  - Internal Supervision: to control and monitor SCADA equipment such as servers, workstations, communications equipment and RTUs.
- A set of off-line services providing the following support functions:
  - Reporting: to generate, edit and print various reports from archived data of daily operations.
  - Engineering utilities**:** to perform database administration, including configurationof the SCADA database, edit graphical user interfaces to create displays, dialogue boxes, etc. and set user access controls.

8. Systemic Functional Requirements

8.1. Overview

The overall Tram SCADA System architecture must have the following attributes required for a real- time environment:

Table 5: Systemic Functional Requirements

ATTRIBUTE	FUNCTIONS
Computer-based	• Platforms for all required applications, integration and connectivity; and to meet performance requirements such as redundancy, fault-tolerance, and system loading conditions
Flexible architecture	• That utilises a distributed database model to provide improved reliability and expandability, and • To support implementation of additional applications that are not constrained by the system data model, and.
Scalable platforms	• To achieve performance requirements such as worst-case peak / avalanche conditions, input-to-display responses times, failover times and spare capacity
Graphical operator interfaces	• That are logical and simple to use for operator interaction and for the creation or alteration of databases for system reconfiguration by SCADA engineers
Open communication protocols	• That are industry-standard and independent of individual vendors
Communication systems	• That provide a secure interface via data communications technology, including TCP/IP based network solutions, and • That operate predictably when field communications have failed
Common infrastructure	• To provide standard functionality such as data acquisition, real-time database, alarm and event monitoring, historical data logging & archiving, reporting and user access control.

8.2. Equipment Interface Requirements

Table 6: Typical TRAM SCADA SYSTEM Equipment Interfaces

ITEM	REQUIREMENT

Outstations - Process equipment interfaces	• Electrical interface criteria to the outstation process equipment (e.g., protection relays / IED's and hardwired connections). • Interface conditions to SCADA equipment • Power supply to the outstation process equipment
Data communications equipment (DCE)	• Interface between DCE and the data transmission channels & data transmission media. • Power supply to data communications equipment, if the DCE is not an integral part of any SCADA equipment. • The LAN switches, routers, LAN extenders or media converters (as required with copper or OFC medium respectively), bandwidth management hardware & software and networking wiring etc. in RCC must be within the scope of supply of successful SCADA tenderer. • Bandwidth and frequency allocations of data channels.
Master Station Equipment	• Interface between SCADA equipment and DCE • Interface between operator's workstation and SCADA server equipment. • Power supplies to SCADA equipment.

8.3. Data Acquisition and Processing Functional Requirements

Table 7: Typical SCADA Data

ITEM	REQUIREMENT
Input & acquisition of monitored information	• Single point information (e.g., for alarms, state information, etc.) • double point information with / without intermediate states (for circuit-breakers, isolators, etc.) • integrated values for tele counting (e.g., energy values). • measured values (analogue or digital) for telemetering. • time tagging requirements. • group / common alarms derived from digital /analogue information. • System information (e.g., equipment failure alarms, etc.);
Output & presentation of information	• status information • double point information with / without intermediate states • alarms, group alarms, common alarms • pulse output or persistent indication of integrated values • analogue or digital display or measured values • information logging • data storage functions
Command inputs	• switching commands: single commands / double commands • set point commands: values transmitted to controlled equipment. • adjusting commands: to change state of operational equipment having more than two states. • regulating commands (analogue or digital) • select and execute commands. • command sequences. • group commands: addressed to several items of equipment. • commands related to the system itself • interrogation commands • check commands to ensure equipment is functioning correctly
Command outputs	• single commands • double commands with / without supervision of faulty states • set point commands with / without validity indication and storage. • adjusting commands • command sequences

The designer must develop I/O schedules to describe the data acquisition, data processing and data quantities relevant to each site. The format of the I/O schedules must comply with existing templates to ensure integration with the existing TRAM SCADA SYSTEM (these can be downloaded from existing SCADA server and can be provided to designer upon request).

8.4. RTU Functional Requirements

Table 8: Minimum RTU Requirements

ITEM	REQUIREMENT
General	• Must be modular and utilise plug-in I/O modules, function modules, and communication modules. • Signal I/O modules must be hot swappable. • Must utilise high-speed CPU and communications processors. • Must be capable of pre-processing local process data. • Must include self-diagnosis and error reporting functions. • Must be capable of synchronization by an external time signal (e.g., NTP)
Firmware	• Must be the latest stable release
RTU Programming	• Parameter assignment and programming must use AS/IEC 61131-3 languages only. • RTU must have the capability to be re-programmed remotely or locally
Program & Data Storage	• Must use non-volatile memory
Data exchange	• Data exchange with field devices is dependent on equipment selection and configuration. • The use of application protocol converters (e.g., Profibus to DNP3) is permitted, but should be minimised. • Coordinate with SAPN to confirm the application data exchange
Diagnostic Interface	• Must include an external port to plug in a diagnostic/maintenance laptop
Time Synchronization	• Accurate clock Synchronization in a RTU depends on knowing the time taken to transmit a Telecontrol message to it from the central Controlling station containing the master clock time thereby permitting an allowance to be made for the transmission time during synchronization.

8.5. Data Transmission Functional Requirements

The TRAM SCADA SYSTEM must communicate over data transmission networks provided by DIT Communication Principles document (refer to section 4 for doc. N.). Data transmission must comply with the following functional requirements:

Table 9: Minimum Data Transmission Network Requirements

ITEM	REQUIREMENT
Data transmission channels	• Provide redundant data channels between each RTU and the master stations. • Provide redundant WAN links between duplicate SCADA servers at the ROC and BCC • Coordinate with DIT Communications Principles for optical fibre and transmission systempoints of presence at each site
Data link configuration	• Communication paths & media used for data links must meet the requirements specified by DIT Communication Principles document. • Data link transmission speeds must meet the requirements specified by DIT Communication Principles document.
Data transmission protocols	• Refer to DIT Communication Principles document.
Data security	• Network switch & router ports not in use must be locked

Failover	• Redundant data communications equipment must be configured to automaticallyfailover to the available channel
Transmission initiation mode	• Refer to DIT Communication Principles document for data transmission initiation modes. Note spontaneous and cyclic data transmission (not polling) is applied on the existing ATN TRAM SCADA SYSTEM data network.
Transmission errors	• The ratio of undetected data transmission errors must not be greater than 10E-8.
Data flow conditions	• The TRAM SCADA SYSTEM design must prevent avalanche data flows that flood an operator with spurious alarms (e.g., on failure of data transmission)
Time Synchronization	• A GPS receiver with antenna must also be provided to synchronize the timing of the servers with that of standard satellite timing. This must ensure that all the date/time stampings of the reports generated by the SCADA system would be accurate & hence comparable to any external report

8.6. Server Functional Requirements

Process and historical servers must comply with the following functional requirements:

Table 10: Minimum Server Requirements

ITEM	REQUIREMENT
Process Servers	• Must be duplicated to meet the required availability target. • Must be supplied with real-time, multi-tasking operating systems. • Must have the capacity to meet worst-case system failure scenarios. • Must be synchronized by external time signal (e.g., NTP) • Must manage data acquisition from the process, control processing, events, alarms,and internal supervision. • Must time-stamp process messages to millisecond precision, • Must provide seamless transfer of control from master server to standby server with no loss of data. • Must provide removable media to allow loading & storage of operating system andconfiguration data. • Must allow configuration data to be loaded via a data network interface. • Should use solid-state hard drives for reliable operating system and process software
Data Storage	• Must either provide the historical data server functions listed below or manage theflow of data to be archived to historical data servers. • Must interface to the Operational Control Centre (OCC) system and provide indicationsof the traction power supply state of each electrified track
Historical Data Servers	• Must be duplicated to ensure that no single fault causes loss of historical data. • Must include sufficient storage for a minimum 6-month period. • Must provide indications to alert the operator when the historical data storage isreaching capacity, and the data should be archived to removable media. • Must include removable media to allow permanent storage of data. • Must allow playback of stored data, including stored data on removable media. • Must allow configuration data to be loaded via a data network interface. • Should use solid-state hard drives for reliable operating system, application software and historical data storage
Operating system	• Must use industry-recognized, international open standards (e.g., Microsoft, Unix) thatprovide a windows-based graphic user interface. • Must fully support the hardware on which it is installed. • Should not be modified from the OS standard, except where a purpose-compiledversion is supplied by the OS developer. • Must be the latest stable release. • Must not require software maintenance (e.g., patches and upgrades)

Application Software	• Must be the latest stable release. • Must only be configurable using high-level, user-friendly programming languages thatdo not require software coding. The Software must be general-purpose, menu driven,GUI based and fully user configurable. • Must have facility for application engineering with necessary tools and library modules, so that it can be easily customized. It should be possible to customize thesoftware to specific need of mimic and tabular displays, representation of various equipment and devices. • Must be possible to create new symbols and add to this library. The online features ofthe application-engineering module must allow for upgrades and modifications easily at site. • SCADA software must be capable of working on latest version of Microsoft WINDOWSoperating system or open international certified. • Application software must also include licensed copies of OS for all terminals, LAN interface software, diagnostic software, Communication system analysis software, Antivirus Software and any other software essentially required for satisfactory workingof the system. This must also include the software for RTU and / or LAN driver etc. The license fee wherever applicable of any of the above software must be borne by the successful tenderer. • The tenderer must be fully responsible for effective working of SCADA software andmust also provide after sales support, on chargeable basis even after expiry or warranty period as negotiated with end users. • The software must be compatible for working on IEC 60870-5-101 companion standard protocols based on IEC 60870-5-1 to 5 series of standards. It must alsosupport multiple channels for communication to all RTUs. • The architecture of the software must be modular, and it should be possible to upgradeit to the newer versions of operating systems. • The software must give fast response to operator actions and system events. SCADAsystem stability should be sustained during event bursts. The software should be capable to support system working at high-speed data transfer rates achievable over OFC communication networks. • The software/system performance should not degrade with the time as system is continuously up (due to generation of temporary files etc. which the software shouldbe capable of cleaning/deleting automatically). The tenderer must endeavor to ensure no software hanging, requiring restart of system or individual computers.

	• Software data logging functions should have flexible time and event-based sampling from real time process database. All values should be registered with status/value and time stamp. • Complete SCADA application software may comprise of some commercial peripheral software therefore DPTI must be indemnified against claims for infringements on rightsof such software and only the valid licensed copies (CD/DVD's) of complete SCADA application, commercial and peripheral software must be supplied to the purchaser/basic user. • SCADA vendor must provide all necessary run time utilities for successful running of the SCADA application. The utilities supplied by the Contractor along with operating system should be sufficient to independently execute the SCADA software without any problem. • The software should provide menu driven and user-friendly configuration. The configuration must define the various devices, their attributes, and the traction systemspecific details. The configuration of the software must be carried out with the help ofuser/purchaser to cover all details/address/nodes of traction supply operation e.g., Interlocking, locked out signals, protection relays & elements, alarms with attributes, power blocks, parameter settings and display/picture screen properties etc. • The application software must comply with DPTI's ICT ISMF policy on information security. Although the SCADA system with dedicated network must be kept isolated from the internet, it is the responsibility of SCADA vendor study the system vulnerabilities and build the necessary security solutions like firewalls, up to date antivirus software, no remote/e-mail/internet access, user access codes/passwords in the master station software and hardware so that any possibility of a cyber-intrusion or attacks is eliminated. • Application backup and recovery procedures must also be well defined by SCADA vendor and end user must be trained about the security threats and vulnerabilities involved in the systems
Device drivers	• Native device drivers must be supplied
Time Synchronization	• The software should have the facility to synchronize the Host computer clock through GPS. Master station servers must be time – synchronized from the GPS receiver directly and WAN network and through to the traction site RTU's.

8.7. Workstation Functional Requirements

Tram Control workstation computers must comply with the following functional requirements:

Table 11: Minimum Workstation Requirements

ITEM	REQUIREMENT
Workstation PC'S	• Must be duplicated to meet the required availability target, • At least one of the Tram Control workstations must be configurable as a Development &Training workstation. • Must be supplied with real-time, multi-tasking operating systems, • Must be synchronized to the lead (master) process server, unless the (standby) workstation is in Development & Training mode. • Must provide seamless transfer of control from master workstation to standby workstation. • Must have the capacity to meet worst-case system failure scenarios, • Should use solid-state hard drives for reliable operating system and HMI application software data storage. • Must provide removable media to allow loading & storage of operating system and

	configuration data • The SCADA graphics should support zoom in/out facility with clutter/de-clutter function. When zooming in more details (static as well as dynamic data) on the graphics should become visible, and when zooming out the details should get hidden with only salient/important information visible. • The zooming facility should not cause loss of clarity of the displayed information.
Operating system	• Must use industry-recognized, international open standards (e.g., Microsoft, Unix)that provide a windows-based graphic user interface. • Must fully support the hardware on which it is installed. • Should not be modified from the OS standard, except where a purpose-compiled version is supplied by the OS developer. • Must be the latest stable release. • Must not require software maintenance (e.g., patches and upgrades)
Application Software	• Must be the latest stable release in line with server
Device drivers	• Native device drivers must be supplied

8.8. HMI Functional Requirements

The Human Machine Interface (HMI) is how the Tram Controller views the TRAM SCADA SYSTEM and interrogates all monitored devices and subsystems, initiates control switching, notes acknowledgment of command actions, notes and acknowledges alarms, views analogue parameter values, accesses parameter trends and prints reports of the traction power network.

The HMI must comply with the following functional requirements:

Table 12: Minimum HMI Requirements

ITEM	REQUIREMENT
General	• The workstation GUI must be structured using windows-based utilities to be easilyand quickly navigable
User Access	• Must be via secure login. • Must be graded based on each user's authority to view or operate or operate & configure the TRAM SCADA SYSTEM
Application software	• Must be the latest stable release. • Must only be configurable using high-level, user-friendly programming languages that do not require software coding. • Application software on a development workstation must allow the SCADA engineer to implement offline configuration changes quickly and easily to the SCADA database representation of the traction power supply network. • Application software on a Training workstation must allow a trainee to operate arealistic, offline simulation of the TRAM SCADA SYSTEM
Operator Controls	• The Tram Controller must be able to: ○ Select between redundant equipment items to nominate the leading (master) and the standby equipment items. ○ Confirm each remote switching command prior to the execution of the command. ○ Apply a command lock (i.e., lockout) to any controllable device to prevent the execution of commands on that device until the command lock is removed by an

	operator of equivalent authority. ○ Apply a message lock to any monitored or controlled device to suppress message processing for that device. ○ De-couple an RTU (place out of service) for maintenance ○ Operate commands and if the same could not be executed, then a message must be displayed indicating reason(s) for it e.g.: Time out, comms loss, remotedevice no response etc... must be aborted after a predefined period and must not be in queue. ○ Have an option to abort a command before giving the confirmation. ○ See the below minimum inherent features as report status or alarms. a) Online/standby /offline state of SCADA server/communication front ends. b) State of all RTUs. c) State of printers. d) Connection status of all the operator workstation. e) Updated/Correct state of the plant. ○ Have the facility for marking (Manual input) for any alarms, equipment status including manually operated isolators, measurands and limit-settings, through keyboard.
Messages	• All process messages must be viewable in a chronologically sequenced message list, message lists must be searchable and sortable
Alarm Management	• Alarms must be prioritized hierarchically based on the level of urgency. • Minimize alarms for single events. • Each alarm class (priority) must be indicated by a different acoustic tone. • Each alarm class must be signaled by different graphic indications (e.g., colour-coding, fill, text, blinking effects, etc.) on the GUI displays. • All alarms must be displayed in a single Alarm list view, which is chronologicallysequenced. • At minimum, the alarm list must define the date, time (in milliseconds), user, device name and description associated with each alarm. • Alarm lists must be searchable and sortable. • The • Tram Controller / operator is required to acknowledge each alarm. • Must have the facility for alarm acknowledgement with a single click should also be provided in addition to one-by-one acknowledgement. • Must have the facility for time delayed alarm operation e.g., alarm for SVC Tripped 30 min CB closing reminder
Workstation Views	At minimum the following workstation views must be provided: • System view/s that provide an overview of the state of all master station equipment and associated communication links between all devices, • System Help view/s that provide a legend describing all possible states and associated graphic indications (e.g., icons, colour-coding, fill, text, blinking effects,etc.) for all equipment states & alarms displayed in the System view. • Semi-geographical Network view of the complete traction power network, • Network / Switching Station Help view/s that provide a legend describing all possible states and associated graphic indications (e.g., icons, colour-coding, fill, text, blinkingeffects, etc.) for all equipment states & alarms displayed in the Network view and in each Switching Station view. • Separate views for each Switching Station • Separate views of any specialised TRAM SCADA SYSTEM components
Screen Displays	• Must be customizable to allow simultaneous display of: ○ Alarm list ○ System view or System Help view, or Network Help view, ○ Complete semi-geographical view of the traction power network, and ○ Two separate switching station views. • Must be of sufficient resolution to ensure the operator can detect state changes from a seated position at the workstation desk

Iconography and graphic indications	• Icons and graphic indications applied on the workstation GUI should conform to the existing HMI, with the following exceptions: ○ Provide industry-standard icons for new equipment types specified as part of the project works (e.g., motorised trackside isolators) ○ Provide unique colour-coding for each new 600V DC OHL feeding arrangement, asspecified in project-specific documents (e.g., minor sectioning diagram)
Reporting	• The HMI must provide comprehensive reporting functions that allow the Tram Controller or SCADA Engineer to plot, trend and/or print system data, such as measured or integrated process values, etc.

8.9. Auxiliary LV Power Supplies

Redundant LV power supplies are required for all TRAM SCADA SYSTEM equipment. The specific configuration of LV AC and LV DC supplies required to achieve redundancy is locationspecific, as follows:

- Switching Stations: refer to DIT standard “Traction DC Substation Design and Construction – Tram System (TP2-DOC-003520) for the redundant LV AC power supply and station battery requirements.

The LV power supply and associated earthing arrangements to TRAM SCADA SYSTEM equipment must comply with AS/NZS 3000 and AS/NZS 3008.1.1 and must incorporate surge protective devices that comply with Telecommunications Technical Standard (Surge Protective Devices for Telecommunication Applications – AS/NZS 4117) 2015.

TRAM SCADA SYSTEM equipment must be installed in structures that comply with AS/NZS 1768 -Lightning protection.

9. Operational Performance requirements

Traction power SCADA systems are vital to the efficient operation of the Adelaide Metropolitantram network and must be capable of remotely operating the traction power systems continuously, 24 hours a day, 7 days a week.

The AMPRN TRAM SCADA SYSTEM must consist of redundant equipment or fault tolerant equipment throughout to achieve the required high availability and accommodate the operator’s physicallyremote location from the traction power assets being controlled & monitored.

Project proponents for TRAM SCADA SYSTEM works must demonstrate that the works meet or exceed the operational performance requirements specified in this section. This demonstration must comply with the requirements in EN50126 - “Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS).

9.1. Operational Availability

The TRAM SCADA SYSTEM must be available for operational use for greater than or equal to 99.95% of the time (availability class A3 per AS 60870.4).

The specified availability target represents an overall system unavailability time of less than or equal to 4.5 hours per year. The TRAM SCADA SYSTEM is considered unavailable where any of the following conditions apply during normal service on the rail network:

- Loss of any function due to a physical or logical communication failure.
- Loss of any function due to equipment hardware or software failure.
- Loss of any function due to equipment software upgrade.

TRAM SCADA SYSTEM services unavailability must be less than or equal to 3 failure events per year.

TRAM SCADA SYSTEM field assets at outstations may be considered available when the specific outstations are removed from service under a planned track outage, such as during a scheduled track possession.

New or modified TRAM SCADA SYSTEM installations must achieve the availability target by meeting all operational reliability and maintainability performance requirements.

9.2. Operational Reliability

All TRAM SCADA SYSTEM products and systems must be off-the-shelf, industrial-type products and systems with proven application within railway environments.

All TRAM SCADA SYSTEM products and systems must be procured from internationally recognized vendors with a permanent office in Australia. Vendors must be capable of providing ongoing technical support services from Australia for the service life of their installed products and systems.

Proposed TRAM SCADA SYSTEM products and systems specified must not be so mature as to be obsolete or unsupported by the vendor at the end of the required service life.

Consequently, vendors must provide the following to project proponents:

- The date at which the product was released for sale.
- The planned date on which the product will be withdrawn from sale.
- The planned date that product support will be withdrawn, such that spares will not be available and technical support will not be provided.

Project proponents must submit evidence of the above product / vendor requirements.

A Product Technical File (PTF) must be submitted for each item by the Contractor to the Principal's Representative during the design process.

All TRAM SCADA SYSTEM works must apply the following operational reliability principles:

- Single points of failure must be overcome by redundancy or alternative operational procedures.
- The failure of a single component must not result in failure of the associated subsystem or the system.
- The failure of any single component must only result in the loss of the function provided by that component.

9.3. Maintainability

The following maintainability principles must be applied in all TRAM SCADA SYSTEM works:

- Common equipment and components must be provided to minimise spare parts holdings.
- Subsystems, consisting of multiple integrated components, must provide self- diagnosis.
- Component failures must be indicated immediately to allow for repair or replacement.
- Subsystems, consisting of multiple integrated components, must be modular and capable of being placed back into service by the replacement of modular components.
- A single technician must be able to remove, replace and test modular components.
- Spare parts lists must be provided for each repairable component.
- Recommended spare part holdings must be derived from a RAM Demonstration, which must specify the smallest permissible Line Replaceable Units for all equipment types.
- RTU's, servers and workstation PCs must not require routine or planned maintenance.
- Integrated fans and internal batteries are not permitted in any computing equipment (containing a CPU / microprocessor), including RTU's, servers, workstation PC's, protocol converters, etc.

9.4. Expandability

TRAM SCADA SYSTEM' must be designed to allow the addition of new equipment to be supervised in future, without the need to replace existing equipment.

Hardware expandability:

- The addition of new equipment must be feasible by the simple addition of cards or racks / shelves on a modular basis.
- Outstation RTUs – provide a minimum 20% spare capacity for each type of I/O used at each site. Provide additional empty slots on the RTU backplane where the required spare capacity cannot be met on procured I/O cards.
- Equipment enclosures – provide a minimum 20% useable space capacity within panels / racks to allow the installation of additional equipment in future.

Software expandability:

- The addition of software-managed items must be carried out by modification of parameter databases / tables.
- The size of the parameter databases / tables must not constrain the addition of new items.
- Software licenses procured must include tag counts for the required spare I/O capacity.

9.5. Security

Provide a secure TRAM SCADA SYSTEM data network resilient to unauthorised access and vandalism. The data network must comply with:

- Communications Network Principles and Practices for Public Transport - Engineering Standard (PTS-AR-10-CN-SPE-00200400), Section 17 – Security,
- the South Australian Government's "Information Security Management Framework (ISMF DPC/F4.1), and
- AS/NZS ISO/IEC 27002 Information Technology–Security techniques–Code of practice for information security Controls, Section – Physical and environmental security".

9.6. Control Integrity

The TRAM SCADA SYSTEM must not provide electrical safety functions required to mitigate the risk of harm to passengers, staff or the public from electrical faults within the electrified areas. These regulated electrical safety functions must only be provided by:

- Independently operated HV & LV electrical switchgear and associated protection devices installed at switching stations to detect and interrupt electrical faults.
- Earthing & bonding provisions at switching stations, and on the wider electrified tram overhead line network, to dissipate electrical faults safely.

The integrity of traction power controls must only depend on local substation automation controllers (e.g., IEDs / protection relays) serving the primary electrical elements at each outstation. That is, the integrity of traction power controls must not depend on the SCADA and/or data transmission network systems and subsystems.

Interlocking rules for each outstation's primary electrical elements must only be implemented within the local substation automation controllers (e.g., IEDs / protection relays) serving that outstation.

The local substation automation system (e.g., IEDs / protection relays) serving the primary electrical elements at each outstation must ensure that no unsafe states will occur regardless of any SCADA control inputs to the local substation automation system.

Remote control of the primary electrical elements at outstations (e.g., controlled motorised switchgear) must only be initiated from the Tram Controller workstation at the master stations.

9.7. Data Integrity

TRAM SCADA SYSTEM design must incorporate data integrity levels.

9.8. Timing Precision

All field RTU's must be capable of time-stamping event data received from field equipment to a precision of ±1 millisecond.

9.9. Response Times

TRAM SCADA SYSTEM must provide the following operational response times:

Table 13: Response times

TERM	DEFINITION	MAXIMUM VALUE
RTU processing time	Elapsed time for an RTU to complete a single execution of its program	100 milliseconds
Operator control action	Elapsed time between a controller-initiated control action and HMIupdate (subject to acknowledgement by the RTU)	1 second
Tram Control Workstation screen load time	Elapsed time to load the active TRAM SCADA SYSTEM application server localdata to the controller Workstation HMI	1 second
Spontaneous messaging time	Elapsed time between a spontaneous field condition input to an RTU and notification on the controller Workstation HMI	3 seconds
TRAM SCADA SYSTEM Server changeover time	Elapsed time to transfer system control from lead Master server to standby Master server (or vice versa) with no data loss	3 seconds
Data bearer failover detection time	Elapsed time between the detection of failure of A or B communications path on any LAN or Control Bus and notification on the controller Workstation HMI	3 seconds
System restart time	Elapsed time for the TRAM SCADA SYSTEM to reach operational capability after acold restart of all system components	2 minutes

9.10. Equipment Service Life

TRAM SCADA SYSTEM hardware must be fit for the intended purpose for a minimum service life, calculated from the date the equipment is commissioned into service, as follows:

Table 14: Equipment Service Life

EQUIPMENT	SERVICE LIFE
Master Station IT equipment	7 years
All other equipment (excluding cables and cable reticulation)	15 years
Cables and cable reticulation associated with traction power SCADA Systems	30 years

9.11. Software Service Life

TRAM SCADA SYSTEM software must be fit for the intended purpose for the service life of the equipment on which it is installed, calculated from the date the equipment enters service.

9.12. Environmental Performance

TRAM SCADA SYSTEM equipment must achieve service life and reliability, availability and maintainability (RAM) requirements under the following environmental conditions:

Table 15: Equipment Environmental Conditions

CONDITION	RANGE / COMPLIANCE
Ambient operating temperatures – Air-conditioned installation	-5°C to 40°C
Ambient (shade) operating temperatures – Field installation, not air-conditioned [**Note 1**]	-5°C to 55°C
Storage temperatures	-10°C to 60°C
Temperature shock changes	±10 °C

Relative humidity (non-condensing)	5% to 95%
Altitude	1000 metres
Solar radiation	1100 W/m2
Ground acceleration (seismic rating) [**Note 2**]	0.2 g
Ingress Protection - Indoor equipment enclosures & housings [**Note 3**]	IP 21 (per AS 60529)
Ingress Protection - Outdoor equipment enclosures & housings [Note 3]	IP54 (per AS 60529)
Atmospheric Corrosion - Indoor equipment [Note 4]	C2 (per AS 4312 \ AS/NZS 2312.1)
Atmospheric Corrosion - Outdoor equipment [Note 4]	C4 (per AS 4312 \ AS/NZS 2312.1)
Electromagnetic compatibility - Field /outstation equipment - [Note 5]	EN50121 (set)
Electromagnetic Compatibility - Master Station equipment - [Note 6]	AS/NZS 61000.6.2 AS/NZS 61000.6.3

Note 1: Air temperature in direct sunlight may be up to 15°C above shade temperature.
Note 2: Applies to As-installed equipment. Field equipment (except cables) supplied for installation must comply with AS 60068.2 ‘Environmental testing – Tests’.
Note 3: Provide heat dissipation calculations to demonstrate that internal temperature build-up within equipment enclosures and housings does not exceed the maximum operating temperature of any enclosed equipment. Natural ventilation of the enclosure or housing is preferred. Where dedicated mechanical ventilation or air- conditioning is provided to the SCADA equipment enclosure or housing to dissipate heat, demonstrate that the dedicated mechanical ventilation or air-conditioning system meets the traction power SCADA system service life and component RAM requirements.
Note 4: A lower atmospheric corrosivity category for outdoor equipment is only permitted where a durability assessment is provided to demonstrate that the specific site's proximity to the coast, local pollution environment and/or atmospheric microenvironment (e.g., air-conditioned room) complies with the proposed alternate category.
Note 5: Field Equipment must be immune to, and comply with, the relevant electromagnetic emissions limits in EN50121-2 'Electromagnetic compatibility - Part 2: Emission of the whole railway system to the outside world'. EMC Compliance certificates are required for all equipment.
Note 6: EMC Compliance certificates are required for all equipment.

10. General – Design Requirements

Detailed designs must provide sufficient information to permit project proponents to proceed to procurement, manufacturer and construction of all aspects of the project-specific scope. Contractual documents will specify project scope and associated design deliverables, whichmay include the following:

Table 16: Typical Design Requirements

ITEM	REQUIREMENT
Project Plans	• Project-specific management plans including: ○ Design and Engineering Management Plan ○ Requirements Management Plan ○ Safety Requirements apportionment ○ Systems Engineering Management Plan ○ Technical Interface Management Plan ○ Verification & Validation Plan

Configuration Design Report	• A design report summarising the design basis, design inputs and design outputs with respect to:
	  ○ System topology & configuration
	  ○ Equipment interfaces
	  ○ Data acquisition system design
	  ○ RTU design and configuration
	  ○ Data communication network design & settings
	  ○ Server, Workstation and Data storage design and configuration
	  ○ Detailed HMI design, etc.

Other Reports	• RAMS Analysis & Report, including recommended spares holdings. • Testing & Commissioning Requirements
System Design & Programming	• RTU configuration, customization, and programming (e.g., interlocking, isolation, propagation rules and control logic requirements applicable to traction power devices at each outstation) • Process server software configuration, customization, and programming • Historical data server software configuration, customization, and programming • HMI application software configuration, customization, and programming • Database administration, including engineering utilities. • Training simulator
Signalling I/O Schedule/s	• Schedules detailing all hardwired and serial/networked I/O required to control and monitor each site, formatted for compatibility with the SCADA database
Hardware Specifications	• RTU specifications • Communications equipment specifications • Process server equipment specifications • Historical data server equipment specification • HMI and display client equipment specifications
Design Drawings	• System topology drawings (layout and operation of the system) • Site / equipment specific detailed schematics (block diagrams, logic, wiring, earthing, etc.) • Site / equipment specific detailed technical drawings • Equipment lists
Calculations	• Capacity calculations (e.g., equipment capacity, spare capacity, heat loading, cables, etc.) • Supporting datasheets
Fabrication Drawings	• Developed by manufacturers to manufacture / fabricate equipment

11. General – Testing and Commissioning Requirements

The TRAM SCADA SYSTEM designer must identify all testing & commissioning requirements for all equipment, subsystems, and systems in the project specific TRAM SCADA SYSTEM design.

Project proponents (e.g., contractors) must develop a Testing & Commissioning Plan, including proposed hold points, for endorsement by the SAPTA system engineer electrical lead prior to the manufacture or construction of any TRAM SCADA SYSTEM equipment or systems.

The Testing and Commissioning Plan must include the order and timing of all factory acceptance tests, site acceptance tests, commissioning testing and system integration tests, as relevant to the project.

Project proponents must notify the SAPTA system engineering electrical lead4 weeks in advance of each test, who may elect to attend or send a representative.

11.1. Factory Acceptance Testing

The following TRAM SCADA SYSTEM equipment must undergo Factory Acceptance Testing (FAT) at the manufacturer's premises before delivery to site:

- Remote Terminal Units (RTU)
- RTU panels/racks
- Marshalling panels
- Servers
- Server panels/racks
- Communication panels/racks

Project-specific Inspection and Test Plans (ITP) must be developed to document FAT procedures for each type of equipment to be tested and must be endorsed by the designer and the SAPTA system engineering electrical lead (or nominee) before the conduct of the relevant FAT.

The manufacturer must sign a release certificate upon successful completion of each FAT and attach a copy to the tested equipment for delivery to site.

11.2. Site Acceptance Testing

Site Acceptance Testing (SAT) must verify the condition, layout, functionality and operation of all TRAM SCADA SYSTEM equipment, subsystems and systems installed at each site.

Project-specific ITP must be developed to document SAT procedures for verification testing of all site-specific equipment, subsystems and systems, and must be endorsed by the designer and the SAPTA system engineering electrical lead (or nominee) before the conduct of the relevant SAT.

Project-specific SAT-ITP must include relevant tests to verify:

- Condition and layout of all equipment.
- Compliant bonding of all equipment to earth.
- Integrity of power & communication cabling between local equipment (per cabling schedules and network schematics).
- Auxiliary LV power supplies to local equipment (per LV single line diagrams)
- RTU startup, loading of program settings/parameters and diagnostics at outstations (per design & manufacturers data)
- Point-to-point testing: Local station interface and function tests of all signals between the RTU and the local traction power equipment and infrastructure process equipment (per I/O schedules).
- Basic communications network within the master stations
- Control system (server and workstation) startup, loading of project data and diagnostics at master stations (per design & configuration data)
- Interface and function tests of all signals between master station controllers and Workstations.
- Verification of all alarm classes and associated graphic indications on the HMI.

The testers and project proponent must sign a release certificate upon successfulcompletion of each SAT and submit this to the SAPTA system engineering electrical lead for endorsement.

11.3. Commissioning Testing

Commissioning testing must verify the end-to-end functionality and operation of all remotely monitored and controlled field equipment at outstations from the master station.

Conduct commissioning tests after completion of the construction and verification of the data transmission network between master stations and outstations (by others).

TRAM SCADA SYSTEM commissioning must only commence after the completion of testing of any HV/LV equipment that is monitored and controlled (e.g., after secondary injection of HV protection). TRAM SCADA SYSTEM commissioning must be completed prior to energisation

of any HV/LV equipment that is monitored and controlled.

Project-specific ITP must document commissioning test procedures for verification of end-to-end functionality, and must be endorsed by the designer and the SAPTA system engineering electrical lead (or his nominee) before the conduct of the relevant SAT.

Project-specific commissioning-ITP must include tests of all potential failure modes associated with equipment, subsystems, and systems, to verify:

- Testing of communications between master stations and every RTU
- Time synchronization testing between master stations and every RTU
- BCC SCADA redundancy testing
- End-to-end interface and function tests of all remote-control signals from the Tram Controller workstations to all controlled switchgear at each outstation.

The testers and project proponent must sign a release certificate upon successful completion of all commissioning tests and submit this to the SAPTA system engineering electrical lead for endorsement.

11.4. System Integration Testing

System Integration Testing must verify the functionality and performance of the traction power SCADA system in response to the highly variable and potentially severe conditions on an operational railway. SIT must only commence after all project-specific works (e.g., including rolling stock, if relevant) have been completed, tested and commissioned.

System Integration Tests typically include:

- Testing of the stability and reliability of the traction power system and associated TRAM SCADA SYSTEM during operational tests of rolling stock under widely varying headway and tram loading conditions, generating varying voltages, currents, and harmonics throughout the traction power system.
- TRAM SCADA SYSTEM response and recovery to stress tests / failure events induced on traction power and TRAM SCADA SYSTEM equipment, subsystems, and systems (e.g., Short-circuit testing of
- the traction power system, de-energising of a master SCADA server, RTU or communications equipment, etc.)
- Electromagnetic emissions compliance testing on the railway as a whole and at traction power substations (per EN50121).

The testers and project proponent must sign a release certificate upon successful completion of the SIT and submit this to the SAPTA system engineering electrical lead for endorsement.