Master Specification
Part TUN-PMCS-DC1

Tunnel Plant Monitoring and Control Systems

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Government of South Australia
Department for Infrastructure and Transport

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1	Update to FORS – PMCS – STREAMS interface requirements to clarify the language and point to an appendix that describes high level principles for each major subsystem	31/01/2024
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Document Management

Contents

TUN-PMCS-DC1 Tunnel Plant Monitoring and Control Systems

1 General

a) This Master Specification Part sets out the requirements for the design, development, implementation and testing and commissioning of plant monitoring and control systems (PMCS) including:

i) the documentation requirements, as set out in section 2;

ii) the PMCS general requirements, as set out in section 3;

iii) the requirements for integration with other systems, as set out in section 4;

iv) the modes of operation requirements, as set out in section 5;

v) the configuration reporting requirements, as set out in section 6;

vi) the PMCS response plans requirements, as set out in section 7;

vii) the Tunnel power systems PMCS functional requirements, as set out in section 8;

viii) the ventilation system PMCS functional requirements, as set out in section 9;

ix) the air monitoring PMCS functional requirements, as set out in section 10;

x) the Tunnel hydraulic treatment and pumping PMCS functional requirements, as set out in section 11;

xi) the Tunnel carriageway lighting PMCS functional requirements, as set out in section 12;

xii) the Tunnel evacuation systems PMCS functional requirements, as set out in section 13;

xiii) the Tunnel fire detection and suppression systems PMCS functional requirements, as set out in section 14;

xiv) the Tunnel closure systems PMCS functional requirements, as set out in section 15;

xv) the Tunnel voice communication systems PMCS functional requirements, as set out in section 16;

xvi) the wayfinding and positioning systems PMCS functional requirements, as set out in section 17;

xvii) the electronic signs PMCS functional requirements, as set out in section 18;

xviii) the Tunnel facilities PMCS functional requirements, as set out in section 19;

xix) the emergency lighting monitoring requirements, as set out in section 20;

xx) training and simulation platform requirements, as set out in section 21;

xxi) the reliability, Design Life, and functional safety requirements, as set out in section 22;

xxii) the maintainability requirements, as set out in section 23; and

xxiii) the verification requirements and records, as set out in section 24.

b) For the purpose of this Master Specification Part, PMCS includes the following subsystems:

i) PMCS Programmable Logic Controllers (PMCS PLC);

ii) supervisory control and data acquisition (SCADA); and

iii) PMCS communications data network.

c) This Master Specification Part does not apply to applications where stand-alone PLCs are used as controllers for local systems, e.g. motorway sump pumps.

d) The design, development, implementation and testing and commissioning of PMCS must comply with the Reference Documents, including:

i) AS/ISO 10007 Quality management - Guidelines for configuration management;

ii) AS/NZS ISO/IEC/IEEE 12207 Systems and software engineering - Software life cycle processes;

iii) AS/NZS ISO/IEC/IEEE 15288 Systems and software engineering – System life cycle processes;

iv) AS ISO/IEC/IEEE 24748.4 Systems and software engineering - Life cycle management, Part 4: Systems engineering planning;

v) ISO/IEC/IEEE 29148 Systems and software engineering - Life cycle processes - Requirements engineering;

vi) AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems;

vii) AS IEC 61131 Programmable controllers;

viii) IEC 62443 Industrial communication networks - Networks and systems security;

ix) AS IEC 62682 Management of alarm systems for the process industriess;

x) TSI-SP-003 Communications protocol for roadside devices; and

xi) Department Technical Data Requirements for Digital Engineering Projects (Digital Asset Governance Manual) (AM-PRC-003).

2 Documentation

2.1 Design Documentation

a) In addition to the requirements of PC-EDM1 “Design Management”, the Design Documentation must include:

i) PMCS architecture as required by section 3.1f);

ii) PMCS functional software design report as required by section 3.1i);

iii) nominated PLC platform and datasheets as required by section 3.1n);

iv) systems analysis and design report as required by section 3.1o);

v) PLC I/O list as required by section 3.2.1m);

vi) nominated SCADA platform and supporting documentation as required by section 3.3.1c);

vii) SCADA style guide as required by section 3.3.1e);

viii) SCADA access control and permission levels as required by section 3.3.2e);

ix) management details for licences for inactive and disconnected sessions, as required by section 3.3.4d)vii);

x) as part of the IFC Design Documentation, evidence that the SCADA subsystem has capability to deal with an additional 20% data points over the number of data points identified in the IFC Design Documentation, as required by section 3.3.6a);

xi) SCADA alarm philosophy as required by section 3.3.8e);

xii) alarm list as required by section 3.3.8g);

xiii) proposed trend data points and sampling frequency as required by section 3.3.11i);

xiv) PMCS communication data network design as required by section 3.4.1m);

xv) analysis of the PMCS communication data network as required by section 3.4.1o);

xvi) interface control documents as required by section 4.2a);

xvii) PMCS response plans as required by section 7.1h);

xviii) the timing and sequencing of the PMCS Tunnel closure response plan as required by section 7.2.2b); and

xix) the timing and sequencing of the PMCS Tunnel closure response plan as required by section 7.3.2b).

3 PMCS general requirements

3.1 General

a) The PMCS must provide monitoring and control of Tunnel functions provided by the following systems and network, including:

i) PMCS communications data network;

ii) Tunnel power systems;

iii) ventilation systems;

iv) air monitoring;

v) Tunnel hydraulic treatment and pumping;

vi) Tunnel carriageway lighting;

vii) Tunnel evacuation systems;

viii) Tunnel fire detection and suppression systems;

ix) Tunnel closure systems;

x) Tunnel voice communication systems;

xi) Tunnel wayfinding and positioning systems;

xii) Tunnel facilities;

xiii) emergency lighting; and

xiv) any other systems as required by the Contract Documents.

b) The PMCS must be developed in accordance with PC-EDM6 “Systems Engineering Management”.

c) The PMCS architecture must be based on the use of:

i) an industrial programmable controller in accordance with section 3.2;

ii) graphical user interface (GUI) based on an industrial SCADA system in accordance with section 3.3; and

iii) dedicated PMCS data communications network in accordance with section 3.4.

d) The PMCS architecture must be in compliance with the manufacturer’s specifications for the selected hardware.

e) The PMCS architecture must include:

i) the PMCS system architecture;

ii) the hardware architecture design for:

A. the SCADA subsystem; and

B. PMCS PLC subsystem; and

iii) the software architecture design for:

A. the SCADA subsystem; and

B. PMCS PLC subsystem.

f) The PMCS architecture required by section 3.1e) must be submitted with the Design Documentation.

g) The PMCS software architecture must be based on the primary control logic being implemented in the PMCS PLC.

h) The PMCS Tunnel functions must continue to function in the event of unavailability of:

i) STREAMS; or

ii) SCADA.

i) A PMCS functional software design report must be developed and submitted with the Design Documentation.

j) All PMCS functions must be designed to be fail-safe and capable of manual override.

k) The following must be housed within PMCS equipment cabinets in accordance with TUN-ME-DC4 “Tunnel Equipment Cabinets”:

i) PMCS PLC equipment; and

ii) active PMCS networking equipment.

l) PMCS equipment cabinets required by section 3.1j) must be installed within electrical equipment rooms (EERs), computer equipment rooms (CERs) or plant rooms.

m) PMCS equipment, excluding the PMCS PLC, located within CERs may be installed in 19” computer equipment cabinets.

n) The nominated PLC platform, including datasheets, must be submitted with the Preliminary Design Documentation.

o) A systems analysis and design report that demonstrates that the proposed PMCS design will achieve the performance requirements of this Master Specification Part must be submitted with the Design Documentation.

3.2 Programmable controller

3.2.1 General

a) The PMCS PLC architecture must utilise:

i) an industrial-type modular PLC system compliant with AS IEC 61131 Programmable controllers; and

ii) a redundant architecture that is configured for high availability that provides bumpless transfer of control to the standby PLC in the event of failure of the primary PLC.

b) The primary and standby PLC central processing units (CPU) must be installed in separate PLC racks.

c) PLC CPUs configured in a redundant arrangement must be diversely located in separate areas that are fire separated in accordance with the requirements derived from TUN-FIRE-DC3 “Tunnel Fire Engineering”.

d) PLC input and output modules must not be installed in the same PLC rack as PLC CPUs.

e) PLC communication modules used to provide an interface to other devices or systems must not be installed on the same PLC rack as the PLC CPUs.

f) The PMCS must be designed such that the commissioned PMCS PLC system has:

i) 50% spare memory;

ii) scan times of less than 100 ms;

iii) I/O update times of less than 100 ms;

iv) at least 10% additional spare I/O points, of each type in each PLC rack location;

v) at least 10% additional spare rack space with a minimum of 2 slots in each PLC rack location; and

vi) at least 20% spare power supply capacity at each PLC rack.

g) PLC racks must have redundant power supplies with fault and status reporting.

h) PLC rack power supplies used in a redundant configuration must be fed from separate circuit breakers.

i) PLC CPU racks power supplies used in a redundant configuration must be fed from diverse switchboards.

j) The PMCS PLC operation must not be affected by a single point of failure in the electrical power system.

k) Loss of a PLC rack power supply must generate an alarm in SCADA.

l) PLC faults must generate an alarm in SCADA commensurate with the criticality of the fault.

m) A PLC I/O list with the following information must be submitted with the Design Documentation:

i) I/O address;

ii) tag name in accordance with Department Technical Data Requirements For Digital Engineering Projects (Digital Asset Governance Manual) (AM-PRC-003);

iii) description; and

iv) asset identification.

n) For analog I/Os, the PLC I/O list required by section 3.2.1m) must include the following additional information:

i) range;

ii) alarm;

iii) trips; and

iv) set points.

3.2.2 PLC I/O modules

a) PMCS PLC remote I/O racks must be installed in each Tunnel cross passageway.

b) PMCS PLC digital modules must utilise 24V DC signals.

c) PMCS PLC analog modules must utilise:

i) a current based analog signal using one of the following ranges:

A. 4-20mA; or

B. 0-20mA; or

ii) a voltage based analog signal using one of the following ranges:

A. 0-5V;

B. 1-5V;

C. 0-10V; or

D. 1-10V.

d) Each PLC I/O module must be fed from a separate circuit breaker.

e) Power to PLC I/O modules must be monitored, and the device status displayed on SCADA.

f) Loss of power to a PLC module must generate an alarm in SCADA.

g) PLC I/O module faults must generate an alarm in SCADA commensurate with the criticality of the fault.

3.2.3 Input devices

a) Input devices must be connected to the PMCS PLC using:

i) 24V DC digital signals;

ii) volt free contacts;

iii) analog inputs; and

iv) a non-proprietary native communications interface.

b) Where multiple inputs are used in a voted arrangement or for discrepancy checking, such inputs must be connected to separate PLC input modules.

c) All inputs must be configured to be failsafe.

3.2.4 Output devices

a) Where devices controlled by the PMCS PLC are intended to provide redundancy for a PMCS function, then the outputs controlling the devices must be connected to separate output modules.

b) The PMCS must accumulate the hours run for each device controlled by the PMCS PLC.

c) Outputs must be protected from feedback from the switched device.

3.2.5 PMCS PLC security

a) PMCS PLC system components must be protected from unauthorized access by the use of strong passwords which meet the following criteria:

i) minimum 8 characters; and

ii) at least one of each of the following:

A. uppercase character;

B. lowercase character;

C. number character; and

D. special character.

b) Where the PMCS PLC systems support more robust access control features, these must be implemented.

c) Where RADIUS authentication is supported by the PMCS PLC system, this must be implemented to operate with the TrafficNet configuration.

d) The Contractor must set up the passwords for the PMCS PLC system components and provide the passwords to the Department's TrafficNet administrators prior to Handover in a secure format agreed with the Principal.

e) Engineering workstations that can access the PLC system components must support single sign-on (SSO) functionality that integrates with existing TrafficNet SSO facilities.

3.3 SCADA

3.3.1 General

a) A SCADA subsystem must be provided as an interface between operators and the PMCS PLC system.

b) The SCADA software must:

i) be commercially available within Australia;

ii) be locally supported within Australia by the original equipment manufacturer (OEM);

iii) not be published as being retired by the SCADA OEM;

iv) have demonstrated functionality and performance on infrastructure projects of a comparable size and complexity to the Project; and

v) be supported by a pool of Australian practitioners capable of providing technical support independent of the OEM.

c) The nominated SCADA platform, including supporting documentation, must be submitted with the Design Documentation.

d) The SCADA operator interface must comprise a logically configured HMI providing an intuitive easy to navigate operational environment consistent with other SCADA implementations already in use at the TMC.

e) A SCADA style guide must be developed and submitted with the Design Documentation.

f) The SCADA style guide required by section 3.3.1e) and the functional software design report required by section 3.1i) must take account of:

i) integration with existing SCADA implementations already in use at the TMC;

ii) intended use of the platform;

iii) current industry practices; and

iv) human factors analysis.

g) The SCADA solution must be scalable to facilitate its use on operator desktop workstations, fixed ruggedised touch screens or mobile tablets.

h) Each device controlled by the PMCS PLC must have manual controls available in SCADA.

i) Access to manual controls in SCADA must be subject to having sufficient permissions in accordance with section 3.3.2.

j) The manual device controls required by section 3.3.1h) must be available via a separate popup or dialog box that is tailored for the device being controlled.

k) A clear indication must be provided on SCADA that a device is in manual control.

l) Off-site data backup facilities must be provided for the SCADA subsystem consistent with the Department's current server backup arrangements.

m) The SCADA subsystem must provide for the automatic and manual backup all data necessary to restore the SCADA subsystem including:

i) SCADA subsystem configuration data;

ii) historical data gathered by the SCADA subsystem; and

iii) full system snapshots of both virtual and physical machines.

n) The complete restoration of the SCADA subsystem from backups must take less than 4 hours.

o) The SCADA subsystem server and workstations must be capable of being rebuilt using documented procedures in less than 12 hours.

3.3.2 Access control and permissions

a) The SCADA subsystem must include safeguards and industry standard security features to ensure only authorised personnel can access SCADA subsystem functions.

b) The SCADA subsystem must support SSO functionality that integrates with existing TrafficNet SSO facilities.

c) The SCADA subsystem must provide customisable, user role-based access control functionality which:

i) prevents unauthorised access to SCADA subsystem functions;

ii) allows user roles to be defined and revised;

iii) allows personnel to be assigned one or more user roles by an authorised user;

iv) allows access to specific SCADA subsystem functions to be assigned to user roles; and

v) only allows personnel to perform operations authorised by their assigned user roles, including:

A. navigating to configuration pages;

B. allowing changes to setpoints;

C. acknowledging and resetting alarms;

D. changing plant control modes; and

E. resetting counters.

d) Initial configuration of the access control and permissions must align with the existing TMC SCADA access controls and permissions current at time of deploying the SCADA subsystem.

e) For any new SCADA functions and features, the access control and permission levels must be developed in consultation with the Principal and included in the Design Documentation.

f) The SCADA subsystem must have a function that automatically logs out the user after user configurable period based on the assigned user role.

g) A SCADA session on a workstation must automatically log out a user when they log out of that workstation.

3.3.3 Architecture

a) The SCADA subsystem must be configured to provide a fault-tolerant, high-availability solution.

b) The SCADA subsystem must, as a minimum, include the following elements within its architecture:

i) fault-tolerant redundant server arrangement;

ii) each device must have redundant power supplies and network cards;

iii) data storage facilities that are:

A. not adversely affected by server failover;

B. suitable for continuous operation;

C. not adversely impacted by a drive failure; and

D. sized to store all data necessary to enable correct operation including trend data, alarm and event logs;

iv) virtualised client workstation, suitable for installation on operator desktop workstations;

v) centralised SCADA license manager; and

vi) facility to integrate fixed ruggedised touch screens or mobile tablets.

c) Redundant SCADA servers must provide a bumpless failover between servers in the event of a planned or unplanned outage of the active server.

d) Manual changeover of the SCADA servers without impact to SCADA operation must be possible to enable a server to be taken offline.

e) The SCADA subsystem must be highly resilient and deal gracefully with the failure of:

i) application software;

ii) operating system software;

iii) data corruption;

iv) server hardware;

v) power supplies; and

vi) communication data networks.

f) SCADA servers must be equipped with 'lights out' management network cards and associated licenses.

g) Physical SCADA servers must be capable of installation in standard 19" racks.

h) Redundant power supplies in a SCADA server must be fed from separate power sources.

3.3.4 SCADA license management

a) A SCADA licence manager must provide license consumption reports both for devices and operator logins as a live output and as a generated report.

b) The SCADA license manager must identify and display:

i) all SCADA licenses;

ii) unique license identifier;

iii) the license validity and the expiration date (where applicable) for each license;

iv) the current status of each license;

v) the user or computer on which floating licenses are being used;

vi) the computer on which fixed licenses are installed;

vii) number of each type of license in use;

viii) number of each type of license available; and

ix) number of reserved licenses.

c) The SCADA license manager must record:

i) each time a license is used, including;

A. when it is consumed;

B. when it is released;

C. the computer on which the license is used; and

D. the user of the license;

ii) changes to license configurations; and

iii) all SCADA licence management administrator actions.

d) The license manager must provide facility for administrators to:

i) define license access protection rules;

ii) prevent license access from computers on remote networks;

iii) allocate a license to a specific computer;

iv) terminate a session to free up licenses;

v) reserve licenses for specific user groups;

vi) define license release conditions for inactive session based on user type; and

vii) define license release conditions for disconnected sessions.

3.3.5 Time source synchronisation

a) The SCADA subsystem must maintain time synchronisation with an accurate time reference to within +/-100 ms.

b) The SCADA subsystem must source time synchronisation from the Department's TrafficNet Stratum 2 Network Time Protocol (NTP) server.

3.3.6 SCADA performance

a) The IFC Design Documentation must include evidence that the SCADA subsystem has a demonstrated capability to deal with an additional 20% data points over the number of data points identified in the IFC Design Documentation.

b) The design and configuration of the SCADA subsystem must be scalable, in the following areas:

i) performance and speed of CPU's;

ii) main memory capacity;

iii) data storage capacity;

iv) I/O capacity; and

v) network connectivity and capacity.

c) The SCADA subsystem must transition between a powered off state to unrestricted monitoring and control of the motorway in less than 5 minutes including after:

i) an ungraceful shut down of the SCADA subsystem; or

ii) an abrupt power loss causing a shutdown of the SCADA subsystem.

d) Any transition to a degraded state of operations must not cause unexpected or adverse behaviour that could cause a safety hazard.

e) The SCADA subsystem must complete presentation or refresh of a display on any device (e.g. computer monitors) within 500 ms of initiation by an operator.

3.3.7 SCADA general functionality

a) The SCADA subsystem functionality must include, as a minimum, the ability to:

i) monitor all connected field equipment and subsystem I/O;

ii) collect and store data from field devices, and associated event and alarm information to enable the generation of reports and trends;

iii) generate reports using collected data;

iv) enable trends to be generated from collected data;

v) present events and alarms related to PMCS devices;

vi) present the current state of the PMCS devices and systems defined in section 3.1a) in a readily understandable format utilising a graphical representation of the Tunnel system in accordance with the SCADA style guide required by section 3.3.1e);

vii) present information from disparate sources relevant to a PMCS function to enable the operator to rapidly understand the current state of that function; and

viii) provide one or more summary pages for maintenance purposes that include all devices monitored and controlled by the PMCS PLC to:

A. show their current state;

B. show pertinent information for each device;

C. allow change of state to single devices; and

D. allow change of state to logical groups of devices.

b) The SCADA subsystem must enable servers and workstations to be taken offline for updates and maintenance without adversely affecting an operator's capacity to utilise the SCADA subsystem.

c) The SCADA subsystem must enable a permitted user to configure each PMCS user-configurable setpoint.

d) Only permitted users must be able to modify user-configurable setpoints.

e) Each user-configurable setpoint must be protected from unauthorised change based on have permission level.

f) All PMCS user-configurable setpoints must include:

i) a setpoint value;

ii) an upper bound;

iii) a lower bound; and

iv) the permission level required to access and adjust that setpoint.

3.3.8 Alarms and notifications

a) The SCADA subsystem must include alarm management functionality which:

i) allows specific events and conditions to be categorised as alarms;

ii) notifies operators when devices and systems are not operating in the way they are required to, or are otherwise in an abnormal state;

iii) notifies operators of abnormal or unsafe conditions;

iv) notifies the operator that the system has degraded to a state in which compensating measures are required in accordance with the Contract Documents;

v) requires operators to acknowledge the presented alarms;

vi) supports prioritisation of alarms to ensure safety related alarms can be prioritised over less critical plant or device alarms;

vii) provides an audible alert scheme which allows differentiation based on alarm priority and alarm lifecycle steps; and

viii) allows alarms to be suppressed by:

A. an operator shelving the alarm;

B. an operator placing the alarm out-of-service; and

C. the associated device being placed out-of-service.

b) The SCADA subsystem must provide the operator with the tools for displaying alarms based upon:

i) priority;

ii) name;

iii) description;

iv) category;

v) time and date;

vi) type;

vii) keyword; or

viii) any combination of the above.

c) The SCADA subsystem must apply the design principles of AAS IEC 62682 Management of alarm systems for the process industries, with respect to the management of alarms.

d) The SCADA subsystem alarms must have states consistent with:

i) other SCADA applications already in use at the TMC; and

ii) AS IEC 62682 Management of alarm systems for the process industries.

e) An alarm philosophy must be developed in accordance with AS IEC 62682 Management of alarm systems for the process industries, and submitted with the Design Documentation.

f) An alarm rationalisation activity must be undertaken in accordance with:

i) clause 9 of AS IEC 62682 Management of alarm systems for the process industries; and

ii) the criteria specified in the alarm philosophy required by section 3.3.8e).

g) The alarm list produced by the alarm rationalisation activity required by section 3.3.8f) must be submitted with the Design Documentation.

h) Where a candidate alarm is not considered to meet the criteria for an alarm, then it must be treated as an event in accordance with section 3.3.10.

i) The SCADA subsystem must provide a visual indication on Geographic Information System (GIS) map representations or schematic representations when subsystems or devices are:

i) in a degraded state;

ii) in a failed state; or

iii) out of service.

j) The SCADA subsystem must include maintenance event functionality which:

i) allows specific events and conditions to be categorised as maintenance events;

ii) automatically notifies maintainers when devices and systems are not operating in the way they are designed or are required to operate, or are otherwise in an abnormal state; and

iii) allows maintainers to view current maintenance events and previous maintenance event history.

k) The SCADA subsystem must support the automatic notification of selected alarms, maintenance events and events to external parties via electronic communication channels including SMS and email.

l) The alarm log data must, at a minimum:

i) be time stamped when the alarm has a change of state as defined by section 3.3.8d);

ii) be accessible for viewing in SCADA reporting tools; and

iii) be exportable to a CSV file.

3.3.9 Alarm suppression

a) The SCADA subsystem must implement the principles and process detailed in the following sections of AS IEC 62682 Management of alarm systems for the process industries, with respect to alarms suppressed by design:

i) section 11.9 “Alarm suppressed by design”;

ii) section 11.3.2 “Required alarm state indications”; and

iii) section 11.3.3 “Recommended alarm state indication”.

b) The SCADA subsystem must provide for the rationalisation and effective management of consequential alarms resulting from a primary event.

c) The SCADA subsystem must provide for consequential ‘child’ alarms to be associated with one or more primary ‘parent’ alarms.

d) When a parent alarm is active, the SCADA subsystem must suppress the associated child alarms and not present the associated child alarms to the operator.

e) When a parent alarm clears, the SCADA subsystem must display all remaining active child alarms to the operator.

3.3.10 Event logs

a) The SCADA subsystem must record in an event log:

i) operator alarm acknowledgments;

ii) response plan execution and cancellation;

iii) notifications including alarms, maintenance events and other events;

iv) alarm records including the information detailed in section 11.6.2 of AS IEC 62682 Management of alarm systems for the process industries;

v) state changes including change in:

A. any Tunnel system equipment state;

B. Tunnel closure system equipment state;

C. automatic incident detection events monitored by PMCS;

D. any electronic sign message display in response to PMCS command;

E. radio rebroadcast (RRB) or public address (PA) broadcast messages;

F. operation of any ventilation equipment; and

G. any mode of operation;

vi) set point changes;

vii) SCADA subsystem errors and faults;

viii) SCADA subsystem backup events;

ix) PMCS PLC errors and faults;

x) operator logon or logoff events;

xi) operator initiated silencing or suppression and activation of notifications; and

xii) system initiated suppression and activation of notifications including alarms, maintenance events and other events.

b) For each logged event, the SCADA subsystem must record:

i) the time of the event;

ii) the operator initiating the event (if applicable);

iii) the subsystem associated with the event (if applicable); and

iv) the unique subsystem equipment identification associated with the event (if applicable).

c) The SCADA subsystem must allow an operator to configure the following parameters for each of event log file:

i) maximum event log file size; and

ii) maximum number of event log files generated after which the event log files will be sequentially overwritten beginning with the oldest file.

3.3.11 Reports and trends

a) The SCADA subsystem must allow an operator to generate, view and export pre-defined and ad hoc reports including the following as a minimum:

i) fault management statistics for all monitored devices and device types;

ii) plant performance and usage;

iii) energy consumption reports including:

A. ventilation system energy consumption;

B. Tunnel lighting energy consumption; and

C. total Tunnel power consumption;

iv) environmental reports including Tunnel air monitoring instrumentation outputs;

v) ventilation system equipment condition monitoring and runtime reports;

vi) lighting reports and trending showing luminance sensor readings and lighting steps for the Tunnel;

vii) event logs, including:

A. operator logins / logout, including privilege level;

B. operator actions including escalating privilege level;

C. alarms and notifications; and

D. device state changes;

viii) tailored reports from bespoke systems; and

ix) other reports consistent with other Department Tunnel assets.

b) The SCADA subsystem must allow reports to be exported in common industry standard formats.

c) The SCADA subsystem must provide for the graphical representation of time series data or “trend charts.”

d) The SCADA subsystem must allow trend charts to be generated from live operational data or historical operational data for all data sets recorded and logged.

e) The SCADA subsystem must allow an operator to create, save, modify and delete pre-defined and ad hoc trend reports.

f) The SCADA subsystem must collect and store operational data from all devices controlled and monitored by the PMCS PLC.

g) The SCADA subsystem must collect and store operational data from all devices controlled and monitored by the Fire Control System (FCS) that is provided to the PMCS PLC.

h) The sampling frequency for the collection of operational data must be selected to enable the construction of meaningful trends.

i) Proposed trend data sampling frequency for each device and its basis must be provided in the Design Documentation.

j) Trend data must be stored in its native form within the SCADA subsystem for a minimum of 3 years.

k) The SCADA subsystem must provide facility to:

   i) archive trend data in a compressed format to minimise file size;

   ii) automatically archive the trend data to a user-configurable location at a user-configurable frequency; and

   iii) restore trend data from an archived file enabling it to be interrogated using the SCADA trend analysis tools.

l) Export tools must be provided to allow a selection of trend data based on devices and periods to be exported in common industry standard formats.

3.3.12 PMCS function availability status

a) An availability analysis must be undertaken as part of the RAMS analysis process for each PMCS function in accordance with PC-EDM6 “Systems Engineering Management”.

b) Where the availability analysis required by section 3.3.12a) determines that the loss or degradation of a PMCS function warrants the implementation of compensating measures or Tunnel closure, then the SCADA subsystem must provide the following:

   i) a summary page providing the current state for all applicable functions that details:

      A. the function;

      B. indication of the current state of degradation;

      C. degradation level requiring compensating measures to be implemented; and

      D. degradation level beyond which the Tunnel cannot be safely operated (beyond minimum operating conditions); and

   ii) for each function, a graphical depiction of the function that presents the PMCS system elements required to provide the function that details:

      A. the architecture of the system elements in providing the function, acceptable methods include reliability block diagram or fault trees;

      B. the current availability status of each system element;

      C. degradation level threshold requiring compensating measures based on the availability of system elements; and

      D. degradation level threshold requiring Tunnel closure based on the availability of system elements.

3.4 PMCS communications data network

3.4.1 General

a) The PMCS data communications network must be an Ethernet network that enables the communication of data between the PMCS PLC and other system elements, including:

   i) remote I/O racks; and

   ii) PMCS field devices equipped with an Ethernet interface.

b) The PMCS communications data network must be compatible with and connect to the Principal's ITS network through a stateful firewall cluster as defined in RD-ITS-D1 "Design of Intelligent Transport Systems (ITS)".

c) Each member of the firewall cluster required in section 3.4.1b), must be capable of processing the full expected network load (plus at least 50% headroom for future growth and expansion) in real time.

d) The firewall cluster required by section 3.4.1b) must be configured to enable communication to other subsystems connected to the TrafficNet network to achieve the requirements of the Contract Documents whilst maintaining the integrity of the TrafficNet network.

e) The interface between the PMCS field network and the Principal's ITS network must be via redundant Layer 3 Ethernet switches, connected to the firewalls required by section 3.4.1b), configured such that a planned or unplanned outage to a single Layer 3 switch does not interrupt communications between the PMCS and ITS networks.

f) The Layer 3 Ethernet switches required by section 3.4.1e) must be provided in separate locations that are fire separated in accordance with the requirements derived from TUN-FIRE-DC3 "Tunnel Fire Engineering".

g) The PMCS SCADA servers must connect to a dedicated access network using redundant Layer 2 switches, which must be connected to the firewall cluster required by section 3.4.1b).

h) The PMCS PLCs and field devices must be integrated into a field network in accordance with RD-ITS-D1 "Design of Intelligent Transport Systems (ITS)".

i) The PMCS field network forming part of the PMCS communications data network must be:

   i) configured as an independent network physically and logically separate from the Principal's ITS communication network in accordance with RD-ITS-D1 "Design of Intelligent Transport Systems (ITS)";

   ii) a redundant network configured for 'high availability seamless redundancy' ensuring bumpless failover;

   iii) fire separated in accordance with the requirements derived from TUN-FIRE-DC3 "Tunnel Fire Engineering";

   iv) free from any single points of failure; and

   v) optimised for the PMCS PLC platform.

j) All PMCS data communications network equipment not installed in a CER must be environmentally hardened.

k) The PMCS communications data network must comply with the security requirements defined in RD-ITS-D1 "Design of Intelligent Transport Systems (ITS)" as it connects to TrafficNet which is critical ICT infrastructure falling within the scope of The South Australian Cyber Security Framework (SACSF).

l) A PMCS communication data network must be designed to ensure the reliable operation of the PMCS based on the selected PMCS PLC and SCADA architectures operating under full data load with an additional 50% load.

m) The PMCS communication data network design required by section 3.4.1l) must be submitted with the Design Documentation.

n) An analysis must be undertaken on the PMCS communication data network required by section 3.4.1l) to determine the performance criteria required for reliable operation including:

i) latency;

ii) bandwidth; and

iii) jitter.

o) The PMCS communication data network analysis required by section 3.4.1n) must be submitted with the Design Documentation.

p) The maximum PMCS communication data network latency must be the lower of:

i) that determined in section 3.4.1n)i); or

ii) 10 ms between any 2 network access points (NAP) within the PMCS data communications network.

q) There must be a graphical representation of the PMCS communication data network in SCADA which shows the current status of all active network components.

3.4.2 Maintenance WiFi network

a) A maintenance WiFi network must be installed within the PMCS network that provides secure wireless access points (WAP) to enable connection of a SCADA client hosted on a maintenance tablet.

b) The maintenance WiFi network must include a wireless LAN controller (WLC) to allow management and monitoring of the WiFi network by the Department's TrafficNet network administrators.

c) The maintenance WiFi network required in section 3.4.2a), must provide coverage to the following areas:

i) all Tunnel equipment and plant rooms;

ii) the Tunnel monitoring facility;

iii) within all Tunnel carriageway areas;

iv) within all egress passageways;

v) within all services passageways; and

vi) above ground equipment and plant rooms associated with the Tunnels.

d) The maintenance WiFi network required in section 3.4.2a) must minimise spillage into publicly accessible areas outside of the required coverage areas.

e) Power to all WAPs forming part of the maintenance WiFi network required in section 3.4.2a) must be controlled by the PMCS PLC via controls incorporated in SCADA.

f) The maintenance WiFi network must be configured to provide the highest level of security provided by the nominated equipment and agreed with the Principal.

g) The WiFi network must be integrated with the Department's TrafficNet RADIUS servers to provide device and user access controls.

h) The WiFi WLC must support forwarding system logs to the Department's TrafficNet Syslog servers, with the level of logging detail kept locally on the WLC and forwarded to the Syslog server being independently configurable.

i) There must be a graphical representation of the maintenance WiFi network in SCADA which:

i) shows the current status of all WAPs; and

ii) provides the controls to manage the power to the WAPs required by section 3.4.2e).

3.5 PMCS general performance requirements

a) The PMCS must present all alarms on the SCADA subsystem (both visual and audio), status and value changes arising from devices on all relevant control room presentation devices within 1 second of the changes being initiated by the originating device or system process.

b) All control and setting requests for all devices or SCADA subsystem processes must be activated at the target devices or process inputs within 1 second of initiation by the originating operator or system process.

c) The PMCS automated functions must operate within the time required to achieve their intended purpose.

4 Integration with other systems

4.1 General

a) The PMCS must, as a minimum, integrate with:

i) STREAMS;

ii) the FCS;

iii) the PA system;

iv) the RRB system;

v) the automatic incident detection system (AIDS);

vi) the water treatment plant (WTP);

vii) the Tunnel ventilation fan condition monitoring system;

viii) the substation automation system; and

ix) the Asset Management Information System (AMIS).

b) Where the Contractor proposes a PMCS systems architecture which results in interfaces in addition to those required by section 4.1a) to provide an integrated solution, then those interfaces must also comply with section 4.1c).

c) Each interface between the PMCS and the subsystem must be designed to:

i) enable the functional requirements of the Project to be satisfied;

ii) maintain uninterrupted operation in the event of control transitioning from the active PMCS PLC to the standby PMCS PLC;

iii) incorporate features to enable detection of degraded or failed communications, and data corruption; and

iv) respond safely and predictably to an out-of-bound value.

d) A failure of any PMCS interface must not adversely affect the operation of the remaining PMCS functionality.

4.2 Interface definition

a) An interface control document (ICD) must be produced per interface, and submitted with the Design Documentation, to formally define each interface between the PMCS and another system or subsystem.

b) Each ICD must describe:

i) physical interface arrangement;

ii) communications protocol;

iii) any protocol configuration options required to achieve required performance;

iv) structure of any data arrays being exchanged;

v) each data point being exchanged;

vi) data format for each data point;

vii) meaning of each possible logical state for each data point;

viii) boundary limits for each data point;

ix) timing or performance requirements;

x) how the interface integrity will be monitored; and

xi) planned response to interface failure or degradation.

4.3 STREAMS

a) An interface between the PMCS PLC and STREAMS must be provided to enable the exchange of information between STREAMS and the PMCS PLC.

b) The interface between the PMCS PLC and STREAMS must enable all data points exchanged between the PMCS PLC and SCADA to also be exchanged between the PMCS PLC and STREAMS.

c) The Contractor must undertake workshops with the Department's nominated representatives to identify the rationalised set of data points that must be exchanged between the PMCS PLC and STREAMS to support TMC operations.

d) The rationalised set of data points must be consistent with the guidelines provided in Appendix 1.

e) The identification of data points that must be exchanged between the PMCS PLC and STREAMS must be informed by:

i) an alarm philosophy developed in accordance with AS IEC 62682 Management of alarm systems for the process industries; and

ii) an alarm rationalisation activity undertaken in accordance with clause 9 of AS IEC 62682 Management of alarm systems for the process industries.

4.4 Fire Control System

a) An interface between the PMCS PLC and the FCS must be provided to enable the exchange of information between FCS and the PMCS PLC.

b) The PMCS-FCS interface required by section 4.4a):

i) must incorporate the necessary data points to enable all data required by TUN-FIRE-DC1 "Tunnel Fire Detection and Suppression Systems" to be exchanged between the PMCS PLC and the FCS; and

ii) may use a high level interface for the exchange of status information.

4.5 Public address system

a) An interface between the PMCS PLC and the PA system must be provided to enable the exchange of information between PA system and the PMCS PLC.

b) The PMCS-PA system interface required by section 4.5a):

i) must incorporate the necessary data points to enable all data required by TUN-COM-DC1 "Tunnel Voice Communications Systems" to be exchanged between the PMCS PLC and the PA system; and

ii) may use a high level interface for the exchange of status information.

4.6 Radio rebroadcast system

a) An interface between the PMCS PLC and RRB system must be provided to enable the exchange of information between RRB system and the PMCS PLC.

b) The PMCS-RRB system interface required by section 4.6a):

i) must incorporate the necessary data points to enable all data required by TUN-COM-DC1 “Tunnel Voice Communications Systems” to be exchanged between the PMCS PLC and the RRB system; and

ii) may use a high level interface for the exchange of status information.

4.7 Automatic incident detection system

a) An interface between the PMCS PLC and the AID FLUX server that forms part of the AIDS must be provided to enable the PMCS PLC to directly receive alarms from the AIDS.

b) The PMCS-AIDS interface required by section 4.7a) must provide the following alarms to the PMCS PLC:

i) AID stopped vehicle where an automatic PMCS response is required;

ii) AID obscuration (smoke detection) alarm; and

iii) AID fire alarm.

c) The PMCS PLC must:

i) manage multiple alarms generated for the same incident from the AIDS;

ii) manage multiple rapidly recurring alarms for the same incident; and

iii) update status to an alarm that is acknowledged in another system such as STREAMS.

4.8 Water treatment plant

a) An interface between the PMCS PLC and the WTP must be provided to enable the exchange of information between the WTP and the PMCS PLC.

b) The PMCS-WTP interface must incorporate the necessary data points to enable the required control and monitoring of the WTP from the PMCS in accordance with TUN-ME-DC1 “Tunnel Hydraulics Treatment and Pumping”.

4.9 Tunnel ventilation fan condition monitoring system

a) An interface between the PMCS PLC and the Tunnel ventilation fan condition monitoring system must be provided to enable the exchange of information between the Tunnel ventilation fan condition monitoring system and the PMCS PLC.

b) The PMCS-Tunnel ventilation fan condition monitoring system interface must incorporate the necessary data points to enable the required control and monitoring of the Tunnel ventilation fan condition monitoring system from the PMCS in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment”.

4.10 Substation automation system

a) An interface between the PMCS PLC and the substation automation system must be provided to enable the exchange of information between the substation automation system and the PMCS PLC.

b) The PMCS-substation automation system interface must incorporate the necessary data points to enable all data identified in TUN-ME-DC2 “Tunnel Power Systems” to be exchanged between the PMCS PLC and the substation automation system.

4.11 Asset Management Information System

a) An interface between the PMCS and the AMIS must be provided to enable the exchange of information between the AMIS and the PMCS.

b) The PMCS-AMIS interface must incorporate the necessary data points to enable all data identified in PC-EDM5 “Digital Engineering” to be exchanged between the PMCS and the AMIS.

c) The PMCS-AMIS interface must be designed to ensure the safe transmission of data from the PMCS to the AMIS without creating a data access path into the Principal’s secure traffic management networks or from any other network into the PMCS network.

5 Modes of operation

5.1 General

The PMCS must have the following modes of operation:

a) normal mode;

b) pre-fire mode; and

c) fire mode.

5.2 Normal mode

Normal mode must:

a) be the default operating mode; and

b) be enabled when pre-fire mode and fire mode are not active.

5.3 Pre-fire mode

a) Pre-fire mode must become active when one of the following conditions is realised:

   i) PMCS receives an AID fire alarm from the AIDS;

   ii) PMCS receives an AID obscuration alarm from AIDS;

   iii) PMCS receives a linear heat detector (LHD) alarm from the FCS;

   iv) PMCS receives an alarm from the FCS as determined by the Fire Engineering design;

   v) Tunnel smoke detectors indicate smoke present in the Tunnel; or

   vi) Tunnel smoke detectors indicate thermal detection in the Tunnel.

b) Pre-fire mode must remain active unless cancelled by an operator or fire mode becomes active.

c) SCADA must provide the facility to cancel pre-fire mode.

d) The STREAMS interface required by section 4.3 must include a pre-fire mode cancel facility.

5.4 Fire mode

a) Fire mode must become active when one of the following conditions is realised:

   i) operator sets a fire location in SCADA;

   ii) operator sets a fire location in STREAMS;

   iii) operator confirms that a fire alarm is valid in SCADA;

   iv) operator confirms a fire alarm is valid in STREAMS; or

v) one of the following active alarms is unacknowledged by the operator in a user-configurable period:

A. AID fire alarm from the AIDS;

B. AID obscuration alarm from the AIDS;

C. LHD alarm from the FCS; or

D. Tunnel smoke detectors indicate smoke present and indicate thermal detection in the Tunnel.

b) Once activated, fire mode must remain active until cancelled by an operator.

c) SCADA must provide the facility to cancel fire mode.

d) The STREAMS interface required by section 4.3 must include a fire mode cancel facility.

6 Configuration reporting

6.1 System configuration status reporting

a) The PMCS must include the facility for personnel with appropriate privilege level to generate a report detailing the current configuration of the PMCS for the following subsystems:

i) PLC system, as detailed in section 6.1b);

ii) SCADA subsystem, as detailed in section 6.1c); and

iii) PMCS data communications network, as detailed in section 6.1d).

b) The PMCS PLC system configuration report must include:

i) the physical configuration of each PLC rack;

ii) firmware installed in each PLC module; and

iii) configuration of each PLC module.

c) The PMCS SCADA subsystem configuration report must include:

i) the physical configuration of each SCADA server;

ii) the physical configuration of each client SCADA workstation;

iii) software including version and patches installed on each SCADA server; and

iv) software including version and patches installed on each client SCADA workstation.

d) The PMCS data communications network configuration report must include:

i) active network devices installed on the network;

ii) firmware installed in each active network device; and

iii) configuration of each active network device.

6.2 User-configurable values status reporting

a) The PMCS must include the facility to generate a report indicating the current values of all user-configurable parameters used by the PMCS PLC for control.

b) The PMCS must include the facility to generate a report indicating any changes to user-configurable parameters used by the PMCS PLC for control, for a nominated date range, that includes:

i) user configurable parameter changed;

ii) date of change;

iii) old value;

iv) new value; and

v) identify of user that made the change.

c) The addition or deletion of user-configurable parameters must be considered a change in the context of reporting as described in section 6.2b).

7 PMCS response plans

7.1 General

a) The PMCS must have the facility to implement response plans that enable rapid response to critical events, independent of STREAMS, including:

i) Tunnel closure; and

ii) Tunnel evacuation.

b) The PMCS response plan functionality required by section 7.1a) must be developed in consultation with the Principal and provide for the structured, coordinated and repeatable control of multiple devices including:

i) electronic sign controllable through the PMCS;

ii) Tunnel closures systems;

iii) RRB systems;

iv) PA systems; and

v) Tunnel evacuation systems.

c) The PMCS response plan actions must be performed by the PMCS PLC.

d) The SCADA subsystem must allow an operator to execute and cancel a PMCS response plan.

e) The SCADA subsystem must allow an operator to quickly find and implement a PMCS response plan using a maximum of 3 operator actions to locate, activate and confirm activation of a response plan, with an action being the click of a mouse or pressing of a keyboard button.

f) The PMCS must have the facility to enable automatic activation of a response plan in the event that a defined alarm is not acknowledged in a user-configurable period.

g) Any additional response plans specified as part of a Project assessment or as identified in the Contract Documents must be integrated with the response plans required in section 7.1a).

h) The PMCS response plans must be submitted with the Design Documentation for approval by the Principal.

7.2 Tunnel closure response plan

7.2.1 Activation

The PMCS must have facility to enable the PMCS Tunnel closure response plan to be:

a) manually activated by the operator using the SCADA subsystem; and

b) automatically activated when fire mode becomes active and no other system initiates a Tunnel closure within a user-configurable time.

7.2.2 Actions

a) The PMCS Tunnel closure response plan must coordinate the control of the following devices to effect a safe Tunnel closure:

i) electronic sign controllable through the PMCS, as detailed in section 18; and

ii) Tunnel closures systems.

b) The timing and sequencing of the PMCS Tunnel closure response plan must be developed and submitted with the Design Documentation for approval by the Principal.

c) The PMCS must indicate to STREAMS that a PMCS Tunnel closure response plan is active.

d) Reopening of the Tunnel must be achieved by the operator:

i) selecting a Tunnel opening response plan in STREAMS; or

ii) manually resetting the relevant devices to their normal state using SCADA.

7.3 Tunnel evacuation response plan

7.3.1 Activation

a) The PMCS must have the facility to enable the PMCS Tunnel evacuation response plan to be manually activated by the operator using the SCADA subsystem.

b) Activating the Tunnel evacuation response plan without a Tunnel closure response plan being active in STREAMS or PMCS must generate a warning on SCADA.

7.3.2 Actions

a) The PMCS Tunnel evacuation response plan must coordinate the control of the following devices to enable a safe Tunnel evacuation:

i) Single Line VMS controllable through the PMCS;

ii) RRB systems;

iii) PA systems; and

iv) Tunnel evacuation systems.

b) The timing and sequencing of the PMCS Tunnel evacuation response plan must be developed and submitted with the Design Documentation for approval by the Principal.

c) The PMCS must indicate to STREAMS that a PMCS Tunnel evacuation response plan is active.

d) Whilst the PMCS Tunnel evacuation response plan is active, the operator must have the following manual controls:

i) select and play pre-recorded messages on PA system;

ii) select and play pre-recorded messages on RRB system;

iii) select alternate message to be displayed on electronic signs controllable through the PMCS;

iv) enable evacuation strobe lights; and

v) disable evacuation strobe lights.

e) When the PMCS Tunnel evacuation response is cancelled, the PMCS must revert all devices activated as part of that response plan to their normal state.

8 Tunnel power systems PMCS functional requirements

8.1 General

a) The PMCS must provide control and monitoring facilities for the HV power system through its interface with the HV substation automation system.

b) The PMCS must provide control and monitoring facilities for the LV power system.

c) PMCS alarms identified in TUN-ME-DC2 “Tunnel Power Systems” must be included in the SCADA alarming system, as described in section 3.3.8.

8.2 HV power system

8.2.1 HV power system monitoring

a) The PMCS must provide monitoring and control of the HV power system via the PMCS PLC interface with the HV substation automation system.

b) The PMCS must provide a graphical representation of the HV electrical distribution system, in the form of single line diagrams, that presents the current state of the HV power system components, including:

i) HV transformers;

ii) circuit breakers;

iii) intelligent electronic devices (IEDs);

iv) switches and disconnectors; and

v) earth switches.

c) The PMCS must monitor and display status information for each component of the HV power system in accordance with TUN-ME-DC2 “Tunnel Power Systems”.

d) The SCADA subsystem must display current power values available from the HV substation automation system.

e) The SCADA subsystem must provide a graphical representation of the HV power system that displays the current state of all interlocks or inter-trips.

8.2.2 HV power system control

a) The SCADA subsystem must provide the facility to select pre-defined power distribution configurations, in accordance with the Tunnel’s HV electrical design, to allow the operator to select the HV supply source for each Tunnel.

b) The SCADA subsystem must not provide the ability to select an HV supply source or configuration that will result in a total loss of HV power to a Tunnel.

c) The SCADA subsystem must not provide facility for an operator to request actions that would result in a configuration in the Tunnel HV electrical system that would be in conflict with safety interlocks enforced in the HV substation automation system.

8.3 LV power system

8.3.1 LV power system monitoring

a) The PMCS must provide monitoring and control of the LV power system via the PMCS PLC interface directly with the LV power system components.

b) The SCADA subsystem must provide a graphical representation of the LV electrical distribution system, in the form of single line diagrams, that presents the current state of the LV power system components up to and including the LV distribution boards, including:

i) transformers;

ii) circuit breakers; and

iii) automatic transfer switches.

c) The PMCS must monitor and display the current status of LV electrical equipment in accordance with TUN-ME-DC2 “Tunnel Power Systems”.

d) Display of information on SCADA must be in a format that is readily interpreted by an operator monitoring the LV power system, including:

i) dynamic single line diagrams;

ii) dynamic icons;

iii) indicators;

iv) time based graphs;

v) tables; and

vi) virtual meters.

8.3.2 LV power system control

a) The PMCS PLC must interface with the LV power system components to implement control commands from the SCADA subsystem in accordance with TUN-ME-DC2 “Tunnel Power Systems”.

b) The SCADA subsystem must provide the following controls for LV power system components installed in LV main switchboards:

i) close incoming circuit breaker;

ii) open incoming circuit breaker;

iii) automatic transfer switch (ATS) close to normal source; and

iv) ATS close to replacement source.

c) The SCADA subsystem must not provide facility for an operator to request actions that would result in a configuration in the Tunnel LV electrical system that would be in conflict with interlocks and intertrips incorporated in the Tunnel LV electrical design.

8.3.3 Soft starters

a) The interface between the PMCS PLC and each soft starter must provide:

i) stop control;

ii) start control; and

iii) status indication displayed on SCADA including:

A. run status (running or stopped);

B. current ramp rate setting; and

C. fault indication.

b) Stop start control must be implemented in the PMCS PLC to achieve the functionality defined for the type of device the soft starter is connected to.

c) The ramp rate must be user-configurable.

d) The ramp rate required by section 8.3.3c) must have an initial setting:

i) based on the device being controlled; and

ii) in accordance with the device manufacturer’s recommendations.

8.3.4 Variable speed drives (VSD)

a) The interface between the PMCS PLC and each VSD must provide:

i) stop control;

ii) start control; and

iii) status indication displayed on SCADA including:

A. run status (running or stopped);

B. current speed;

C. power;

D. current ramp rate setting; and

E. fault indication.

b) Stop, start and speed control must be implemented in the PMCS PLC to achieve the functionality defined for the type of device the VSD is connected to.

c) Where the VSD is only used for controlling acceleration, the ramp rate must be user-configurable.

d) The ramp rate required by section 8.3.4c) must have an initial setting:

i) based on the device being controlled; and

ii) in accordance with the device manufacturer's recommendations.

9 Ventilation system PMCS functional requirements

9.1 General

a) Tunnel ventilation functions must be automatically controlled and monitored by the PMCS PLC.

b) The PMCS SCADA must provide facilities to enable Tunnel ventilation system user-configurable parameters to be monitored and changed to allow Tunnel ventilation functions to be tuned for optimal operation.

c) The PMCS must provide manual control of the ventilation system from SCADA at both:

i) a Tunnel ventilation function level; and

ii) for individual ventilation system devices from SCADA.

9.2 Tunnel carriageway ventilation

9.2.1 General

a) The PMCS PLC must implement Tunnel ventilation control required by the Tunnel ventilation system design undertaken in accordance with TUN-ME-DC7 "Ventilation Design".

b) Tunnel ventilation control must be implemented in the PMCS PLC allowing continued automatic operation in the event SCADA is not available.

9.2.2 Ventilation jet fan monitoring

a) Motor resistance temperature detectors (RTDs) installed on ventilation jet fans in accordance with TUN-ME-DC6 "Tunnel Ventilation Equipment" must be monitored by the PMCS PLC.

b) For each RTD installed on a ventilation jet fan:

i) the current value must be displayed on SCADA;

ii) 2 alarms must be provided in SCADA indicating when user configurable thresholds are exceeded;

iii) a trip threshold must be provided, that when exceeded indicates the ventilation jet fan is unhealthy; and

iv) initial threshold values for alarms and trips must be determined in consultation with the ventilation jet fan equipment manufacturers.

c) The PMCS PLC must interface with the Tunnel ventilation fan condition monitoring system installed in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment”.

d) The PMCS PLC must receive condition monitoring values and any alarms provided by the Tunnel ventilation fan condition monitoring system for display on SCADA.

e) Where a condition monitoring alarm is received from the Tunnel ventilation fan condition monitoring system or a condition monitoring value exceeds a user configurable threshold then the ventilation jet fan must be identified as unhealthy.

f) Each circuit breaker associated with a ventilation jet fan must be monitored and if tripped then the ventilation jet fan must be identified as unhealthy.

g) Where motor control or protective devices indicate the ventilation jet fan is drawing excessive current, as determined by the electrical design, after a user-configurable period from being called to run, then the ventilation jet fan must be identified as unhealthy.

9.2.3 Ventilation jet fan control

a) Ventilation jet fans must have the following modes, which must be selectable in SCADA:

i) automatic;

ii) manual; and

iii) off.

b) When in automatic mode, each ventilation jet fan must be controlled by the PMCS in accordance with the Tunnel ventilation system design.

c) When a ventilation jet fan is set to manual mode, the ventilation jet fan must be inhibited from automatic operation except when the PMCS is in fire mode or alternative control is required by the ventilation design.

d) When in manual mode, the SCADA subsystem must provide manual controls for the ventilation jet fans that include:

i) start;

ii) stop;

iii) direction; and

iv) speed where a VSD is used to control power to the ventilation jet fan.

e) When in off mode, the ventilation jet fan must not operate.

f) Where a ventilation jet fan can incur damage due to resonance when running at certain speeds the PMCS must prevent operation at those speeds.

g) The PMCS must limit the number of starts and reversals of a ventilation jet fan in a defined period in accordance with the ventilation jet fan manufacturer's requirements.

h) In fire mode, a ventilation jet fan must not be prevented from operating due to an excessive number of starts in a defined period as required by section 9.2.3g).

i) The PMCS must prevent ventilation jet fans from starting in the opposite direction to their last direction of operation within a user-configurable period.

j) The default value of the user-configurable period required by section 9.2.3i) must be in accordance with the ventilation jet fan manufacturer's requirements.

k) The user-configurable period required by section 9.2.3i) must be reduced to the minimum value recommended by the ventilation jet fan manufacturer for fire mode.

l) If a ventilation jet fan is identified as unhealthy when in normal mode, then it must be considered unavailable and must remain unavailable until the abnormal condition clears and is set to available via SCADA.

m) The Tunnel ventilation system design must determine when ventilation jet fans that are identified as unhealthy become available when in pre-fire and fire mode.

n) When a ventilation jet fan is identified as unavailable, it must be commanded to stop and remain stopped until it is available again, unless fire mode is active.

o) A ventilation jet fan that has been set as unavailable can be started when all of the following conditions are satisfied:

   i) fire mode is active;

   ii) all available ventilation jet fans are already running; and

   iii) additional ventilation jet fans are required to operate to satisfy the Tunnel ventilation system design during fire mode.

p) The PMCS must implement ventilation jet fan duty sharing in accordance with the Tunnel ventilation system design.

9.2.4 Ventilation axial fan monitoring

a) RTDs installed on ventilation axial fans in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment” must be monitored by the PMCS PLC.

b) For each RTD installed on a ventilation axial fan:

   i) the current value must be displayed on SCADA;

   ii) 2 alarms must be provided in SCADA indicating when user-configurable thresholds are exceeded;

   iii) a trip threshold must be provided, that when exceeded, indicates the ventilation axial fan is unhealthy; and

   iv) initial threshold values for alarms and trips must be determined in consultation with the ventilation axial fan equipment manufacturer.

c) The PMCS PLC must interface with the Tunnel ventilation fan condition monitoring system installed in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment”.

d) The PMCS PLC must receive condition monitoring values and any alarms provided by the ventilation axial fan condition monitoring system for display on SCADA.

e) Where a condition monitoring alarm is received from the ventilation axial fan condition monitoring system or a condition monitoring value exceeds a user-configurable threshold, then the ventilation axial fan must be identified as unhealthy.

f) Each circuit breaker associated with a ventilation axial fan must be monitored, and if tripped, then the ventilation axial fan must be identified as unhealthy.

g) Where motor control or protective devices indicate the ventilation axial fan is drawing excessive current, as determined by the electrical design, after a user-configurable period form being called to run, then the ventilation axial fan must be identified as unhealthy.

9.2.5 Ventilation axial fan control

a) Ventilation axial fans must have the following modes, which must be selectable in SCADA:

   i) automatic;

   ii) manual; and

   iii) off.

b) When in automatic mode, each ventilation axial fan must be controlled by the PMCS in accordance with the Tunnel ventilation system design.

c) When in manual mode, SCADA must provide manual controls for ventilation axial fans that include:

   i) start;

   ii) stop;

   iii) direction (where applicable); and

   iv) speed.

d) Dampers associated with ventilation axial fans must be controlled automatically based on the operation of the associated ventilation axial fan in either automatic or manual mode.

e) Reversal of ventilation axial fans is only required where specified in the Tunnel ventilation system design.

f) When in off mode, the ventilation axial fan must not operate.

g) Where a ventilation axial fan can incur damage due to resonance when running at certain speeds the PMCS must prevent operation at those speeds.

h) The PMCS must limit the number of starts of a ventilation axial fan in a defined period in accordance with the ventilation axial fan manufacturer's requirements.

i) In fire mode, a ventilation axial fan must not be prevented from operating due to an excessive number of starts in a defined period as required by section 9.2.5h).

j) If a ventilation axial fan is identified as unhealthy when in normal mode, then it must be determined to be unavailable and must remain unavailable until the abnormal condition clears and is set to available via SCADA.

k) The Tunnel ventilation system design must determine when ventilation axial fans that are identified as unhealthy become available when in pre-fire and fire mode.

l) When a ventilation axial fan is identified as unavailable, it must be commanded to stop and remain stopped until it is available again, unless fire mode is active.

m) A ventilation axial fan that has been set as unavailable can be started when all of the following conditions are satisfied:

   i) fire mode is active;

   ii) all available ventilation axial fans are already running, and

   iii) additional ventilation axial fans are required to operate to satisfy the Tunnel ventilation system design during fire mode.

n) The PMCS must implement ventilation jet fan duty sharing in accordance with the Tunnel ventilation system design.

9.2.6 Ventilation damper monitoring

a) Limit switches installed on ventilation dampers in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment” must be monitored by the PMCS PLC.

b) Limit switches installed on a ventilation damper must be used to display on SCADA:

   i) the open/closed status of each module in the damper; and

   ii) the overall open/closed status of the entire damper.

c) Position transducers installed on ventilation dampers in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment” must be monitored by the PMCS PLC.

d) Position transducers installed on a ventilation damper must be used to display on SCADA:

i) the current percentage open of each module of the damper; and

ii) the overall percentage open of the damper.

e) Ventilation damper actuators with integral torque limit switches in accordance with TUN-ME-DC6 “Tunnel Ventilation Equipment” must be monitored by the PMCS PLC.

f) For each actuator torque limit switch installed on a ventilation damper the alarm status must be displayed on SCADA.

g) Ventilation damper modules must be identified as unhealthy when any of the following conditions are met:

i) the expected module open/close status is not achieved in a user-configurable time;

ii) the expected module position is not achieved in a user-configurable time (modulating dampers only); or

iii) an over-torque alarm occurs.

9.2.7 Ventilation damper control

a) Ventilation dampers must have the following modes, which must be selectable in SCADA:

i) automatic;

ii) manual; and

iii) off.

b) When in automatic mode, each ventilation damper must be controlled by the PMCS in accordance with the Tunnel ventilation system design.

c) When in manual mode, SCADA must provide manual controls for ventilation dampers that include:

i) fully closed;

ii) fully open; and

iii) percentage open (for modulating dampers only).

d) Dampers associated with ventilation axial fans must be controlled automatically based on the operation of the associated ventilation axial fan in either automatic or manual mode.

e) When in off mode, the ventilation dampers must not operate.

f) Ventilation damper modules that are identified as unhealthy must be made unavailable until the condition is cleared.

9.3 Egress passageways

a) Where egress passageways are included in the Tunnel design the requirements of this section 9.3 must apply.

b) The PMCS PLC must implement egress passageway ventilation control in accordance with the Tunnel ventilation system design.

c) Egress passageway ventilation control must be implemented in the PMCS PLC allowing continued automatic operation, in the event SCADA is not available.

9.4 Services passageways

a) Where services passageways are included in the Tunnel design the requirements of this section 9.4 must apply.

b) The PMCS must implement services passageway ventilation control in accordance with the Tunnel ventilation system design.

9.5 Sump ventilation

9.5.1 General

Where sumps are included in the Tunnel design that are intended to capture liquids from the Tunnel or Tunnel portal areas, the requirements of this section 9.5 must apply.

9.5.2 Sump fan monitoring

a) Each circuit breaker associated with a sump ventilation fan must:

   i) be monitored by the PMCS; and

   ii) if tripped, then the sump ventilation fan must be identified as unhealthy in SCADA.

b) Where motor protective devices indicate a sump ventilation fan is drawing excessive current, then the sump ventilation fan must be identified as unhealthy.

c) Dampers associated with sump ventilation fans must be monitored by the PMCS as per the ventilation design undertaken in accordance with TUN-ME-DC7 “Ventilation Design”.

9.5.3 Sump fan control

a) Each sump ventilation fan must have the following modes, which must be selectable in SCADA:

   i) automatic;

   ii) manual; and

   iii) off.

b) When in automatic mode, each sump ventilation fan must be controlled by the PMCS in accordance with the sump ventilation control strategy required by the ventilation design undertaken in accordance with TUN-ME-DC7 “Ventilation Design”.

c) When in manual mode, SCADA must provide manual controls for the sump ventilation fans that include:

   i) start; and

   ii) stop.

d) When in off mode, the sump ventilation fan must not operate.

e) Dampers associated with sump ventilation fans must be controlled automatically based on the operation of the associated sump ventilation fans in either automatic or manual mode, as per the ventilation design undertaken in accordance with TUN-ME-DC7 “Ventilation Design”.

f) If a sump ventilation fan is identified as unhealthy, then it must be considered unavailable and must remain unavailable until the abnormal condition clears and is set to available via SCADA.

g) The PMCS must implement sump ventilation fan duty sharing in accordance with the Tunnel ventilation system design.

9.6 Pressurisation

In addition to the pressurisation of services passageways and egress passageways, the PMCS must monitor and control the pressurisation of escape paths from other underground areas, including plant, equipment, and ancillary rooms, based on fire location in accordance with pre-defined ventilation control strategies defined by the Tunnel ventilation design.

10 Air monitoring PMCS functional requirements

10.1 General

a) The PMCS must continuously monitor air monitoring instrumentation installed in:

   i) Tunnel bores;

   ii) VSOs;

   iii) sumps;

   iv) services passageways and

   v) ambient air monitoring stations, when required by the ventilation design undertaken in accordance with TUN-ME-DC7 “Ventilation Design”.

b) The air monitoring parameters and characteristics to be measured in each area must be in accordance with the Tunnel ventilation design and TUN-ME-DC5 “Supply of Tunnel Air Monitoring Instrumentation”.

c) Air monitoring instruments must be selected with electrical connections that provide a robust interface with the PMCS PLC using either:

   i) analog signals for measured values and digital signals for status indications; or

   ii) communication protocol native to both the instrument and the PMCS PLC, that has a suitable integrity for the intended purpose.

d) The air monitoring instruments must be configured to provide diagnostic information indicating the current state of the instrument.

e) The PMCS must monitor each air monitoring instrument and generate an alarm in SCADA when an instrument indicates via diagnostics that it is failed, or degraded, and requires maintenance.

10.2 In-Tunnel air quality monitoring

a) The PMCS must monitor each in-Tunnel air quality sensor for each measured parameter, and display on SCADA:

   i) the current value of each parameter being measured by each air quality sensor;

   ii) one or more time-averaged values for each parameter being measured by each air quality instrument, with the time averaging criteria specified by the Tunnel ventilation designers; and

   iii) the units of measurement used for each measured values must be in accordance with the Tunnel ventilation design.

b) Where multiple in-Tunnel air quality sensors are installed in a Tunnel to provide redundant measurement, the PMCS PLC must include the necessary logic in accordance with the Tunnel ventilation design to facilitate:

   i) value averaging based on measured values from multiple instruments;

   ii) detection and response to discrepancies between measured values;

   iii) detection and response to failed instruments to enable graceful degradation of the in-Tunnel air quality monitoring system; and

   iv) taking instruments out-of-service for maintenance.

c) The air quality values used for ventilation control derived from the measured values must be displayed on SCADA.

d) Where an air quality instrument has facility to indicate that it requires maintenance, then an alert must be sent to the PMCS for display on SCADA.

10.3 In-Tunnel air velocity sensors

a) The PMCS PLC must implement an air velocity averaging algorithm in accordance with the Tunnel ventilation design to provide an average air velocity in a Tunnel section from the measured air velocity values in that section.

b) A time-averaged air velocity value must be calculated based on the algorithm included in the Tunnel ventilation design for each monitored area.

c) The air velocity averaging algorithm must identify degraded or failed air velocity sensors.

d) The air velocity averaging algorithm must compensate for degraded or failed air velocity sensors.

e) SCADA must display:

i) current air velocity from each instrument; and

ii) averaged air velocity for each Tunnel ventilation section; and

iii) any alarms associated with the air velocity sensors.

10.4 In-Tunnel smoke detection units

a) In-Tunnel smoke detection units must be monitored by the PMCS.

b) SCADA must display the current values of all measured parameters and the status of any alarms or indications generated by each in-Tunnel smoke detection unit.

c) Any smoke or thermal detection alarms must be displayed on SCADA in graphical format clearly showing the detection location.

11 Tunnel hydraulic treatment and pumping PMCS functional requirements

11.1 General

a) The PMCS must monitor and display the current state of each instrument associated with the Tunnel drainage system.

b) The PMCS must monitor and display the current state of each monitored manual or actuated valve associated with the Tunnel drainage system.

c) The PMCS must control and display the current state of each sump pump associated with a Tunnel sump forming part of the Tunnel drainage system.

d) The PMCS must control and display the current state of any booster or transfer pumps installed as part of a Tunnel sump rising main.

11.2 Tunnel sump monitoring

a) The PMCS must monitor for discrepancies between level measuring instruments installed in a sump, and generate an alarm on SCADA in the event of a discrepancy.

b) The PMCS must detect invalid combinations of valve position status per valve, including no position indication after a user-configurable time and generate an alarm in SCADA.

c) The PMCS must detect flow control device arrangements (where fitted) based on current position that would prevent inflow into a sump.

d) The PMCS must detect valve arrangements based on current position and available pumps that would prevent pumping liquid from a sump.

e) The PMCS must generate an alarm in SCADA if an actuated valve does not achieve a commanded position within a user-configurable time.

f) The PMCS must indicate in SCADA that a pump is unavailable if:

i) there is a pump fault;

ii) a circuit breaker is off or tripped that would prevent the pump from operating; or

iii) the current state of the valves on the suction or discharge side of the pump would prevent the correct operation of the pump.

g) The PMCS must generate an alarm in SCADA when there are N-1 sump pumps available.

h) The PMCS must generate an alarm when flow into a sump is prevented due to the current position of all valves controlling inflow.

11.3 Tunnel sump pump control

a) The PMCS must provide automatic and manual control of each sump pump installed in a Tunnel sump forming part of the Tunnel drainage system.

b) The PMCS must automatically control each portal sump pump in accordance with the hydraulic strategy in accordance with TUN-ME-DC1 “Tunnel Hydraulics Treatment and Pumping”.

c) The PMCS must provide facility to enable the operator to manually control each sump pump from SCADA, unless operation is otherwise inhibited.

d) All sump pumps in a sump must be inhibited from operating if a low level is detected in that sump, by either a level transmitter or a level switch located in that sump.

e) The PMCS must monitor the flow rate in a rising main and alarm if the flow rate is low based on the number of pumps in operation.

f) Flow rate alarm setpoints must be user configurable.

g) The PMCS must monitor the pressure in a rising main and alarm if the pressure is low based on the number of pumps in operation.

h) Pressure alarm setpoints must be user configurable.

i) If a flow rate is not detected in the rising main within a user-configurable time and there is low pressure in the rising main when an associated sump pump is started then the PMCS must:

i) generate an alarm in SCADA;

ii) stop the sump pump; and

iii) start an alternate pump in that sump in accordance with the hydraulic strategy.

j) When the PMCS is in fire mode, all sump pumps must be inhibited from automatic operation.

k) When a sump pump is set to manual mode, the sump pump must be inhibited from automatic operation.

l) A warning in SCADA must be provided if manual control of a sump pump is attempted whilst in fire mode.

11.4 Fire foam suppression

a) The PMCS must monitor for discrepancies between hydrocarbon sensors installed in a sump and generate an alarm on SCADA in the event of a discrepancy.

b) The PMCS must monitor the hydrocarbon sensors installed in the tunnel sumps and generate a hydrocarbon detected alarm if the hydrocarbon level exceeds 5% LEL.

c) The PMCS must monitor the hydrocarbon sensors installed in the tunnel sumps and generate a high hydrocarbon level alarm if the hydrocarbon level exceeds 25% LEL.

d) The PMCS must command a release of the fire foam suppression if the hydrocarbon level in the sump exceeds 25% LEL.

e) The PMCS must provide the facility to initiate a manual release of the fire foam suppression in a sump, using a 2-step process that requires the operator initiate the command and then confirm the release command.

12 Tunnel carriageway lighting PMCS functional requirements

12.1 General

a) The PMCS must coordinate the control and monitoring of the Tunnel carriageway lighting.

b) The PMCS must provide control and monitoring of the Tunnel carriageway lighting in accordance with TUN-ME-DC3 “Tunnel Carriageway and Underpass Lighting”.

c) The PMCS must provide 3 Tunnel carriageway lighting control modes:

i) automatic control;

ii) time-of-day control; and

iii) manual control.

d) The PMCS must provide facility to select the Tunnel carriageway lighting control mode.

e) The PMCS must automatically change the Tunnel carriageway lighting control mode if the current mode of operation is not possible due to one or more degradations in the Tunnel carriageway lighting system.

f) The PMCS must correctly control the lighting based on the selected mode in accordance with the lighting control strategies required by TUN-ME-DC3 “Tunnel Carriageway and Underpass Lighting”.

g) The PMCS must not change the lighting level of the Tunnel carriageway lighting at a rate greater than the maximum rate in accordance with TUN-ME-DC3 “Tunnel Carriageway and Underpass Lighting”.

h) The PMCS must not initiate a change in Tunnel carriageway lighting levels that exceeds the specified maximum rate of change of lighting level defined by the lighting control strategy for each zone.

i) Upon mains power loss, the PMCS must set Tunnel carriageway lighting luminaires powered from UPS to night time lighting levels.

j) The PMCS must revert luminaires set to night time levels pursuant to section 12.1i) to their normal operating levels based on mode and Tunnel conditions upon return to mains power following a user configurable period.

12.2 Automatic lighting control

a) When Tunnel carriageway lighting automatic control mode is selected, the PMCS must set the lighting level in each Tunnel lighting zone to the required level based on the automatic lighting control strategy required to be developed in accordance with TUN-ME-DC3 “Tunnel Carriageway and Underpass Lighting”.

b) In the event that the PMCS does not have a valid Tunnel portal luminance level, an alarm must be raised in SCADA and the Tunnel carriageway lighting system must revert to the time-of-day lighting control mode.

c) In the event that the PMCS does not have a valid in-Tunnel illuminance level, an alarm must be raised in SCADA and the PMCS must use the last valid illuminance value to determine the Tunnel lighting level.

12.3 Time of day lighting control mode

a) When time-of-day Tunnel carriageway lighting control is selected, the PMCS must implement the time-of-day lighting control in accordance with the time-of-day lighting control strategy required by TUN-ME-DC3 “Tunnel Carriageway and Underpass Lighting”.

b) The PMCS must provide facility for the user to configure the lighting levels for different times of the day.

12.4 Manual lighting control

a) Manual Tunnel carriageway lighting controls must allow:

   i) manual selection of the lighting level for the Tunnel; and

   ii) the lighting level for any Tunnel lighting zone to be set manually.

b) When using manual control, the minimum carriageway lighting level that can be set in any Tunnel lighting zone must be not less than the night time lighting level.

12.5 Monitoring

a) The PMCS must generate an alarm when a failure is detected in the in-Tunnel carriageway lighting system.

b) The PMCS must generate an alarm when lighting levels in a section of the Tunnel are compromised by a failure in a combination of luminaires or other in-Tunnel lighting system elements.

c) The PMCS must generate an alarm if the measured in-Tunnel illuminance level is lower than the target level by a user-configurable amount.

13 Tunnel evacuation systems PMCS functional requirements

13.1 General

The PMCS must monitor and control the following Tunnel evacuation systems:

a) Tunnel egress passageway doors;

b) exit sound beacons;

c) in-Tunnel directional exit signs;

d) Tunnel emergency exit signs and strobes;

e) egress passageway alcove lighting;

f) low level emergency luminaires; and

g) low level egress guidance lighting.

13.2 Tunnel egress passageway doors

a) The PMCS must monitor and display the status of the egress passageway doors on a graphical representation of the Tunnels, clearly identifying if a door is opened.

b) A door must be considered opened if it is not confirmed in the closed position.

c) An alarm must be generated in SCADA when an egress passageway door is opened.

13.3 Exit sound beacons

a) The PMCS must provide manual and automatic control of the exit sound beacons.

b) The PMCS must provide the following automatic control of the exit sound beacons:

i) energise all exit sound beacons in the incident Tunnel when a Tunnel evacuation is initiated either by STREAMS or by SCADA;

ii) de-energise all exit sound beacons when a public address message is being broadcast; and

iii) de-energise all exit sound beacons when a Tunnel evacuation response plan is cancelled, either by STREAMS or by SCADA.

c) The SCADA subsystem must provide the following manual controls for the PMCS:

i) energise an individual exit sound beacon;

ii) de-energise an individual exit sound beacon;

iii) energise all exit sound beacons in one Tunnel; and

iv) de-energise all exit sound beacons in one Tunnel.

d) The SCADA subsystem must include the facility to configure or select the sounder tones for each exit sound beacon.

e) Where an egress passageway is within a user-configurable distance from an operator declared fire location then the associated exit sound beacon must be inhibited whilst the PMCS PLC is in fire mode.

f) The SCADA subsystem must provide the ability to enable or disable the inhibit function of the exit sound beacon specified in section 13.3e).

13.4 In-Tunnel directional exit signs

a) The PMCS must provide manual and automatic control of the in-Tunnel directional exit signs.

b) The PMCS must provide the following automatic control of the in-Tunnel directional exit signs:

i) energise all in-Tunnel directional exit signs in the incident Tunnel when a Tunnel evacuation response plan is initiated, either by STREAMS or by SCADA; and

ii) de-energise all in-Tunnel directional exit signs when a Tunnel evacuation response plan is cancelled, either by STREAMS or by SCADA.

c) The SCADA subsystem must provide the following manual controls for the PMCS subsystem:

i) energise an individual in-Tunnel directional exit sign;

ii) de-energise an individual in-Tunnel directional exit sign;

iii) energise all in-Tunnel directional exit signs in one Tunnel; and

iv) de-energise all in-Tunnel directional exit signs in one Tunnel.

d) Any in-Tunnel directional exit sign that points in the direction of a user declared incident location that is within a user-configurable distance of the declared incident location must be inhibited whilst the PMCS PLC is in fire mode.

e) The SCADA subsystem must provide the ability to enable or disable the inhibit function of the in-Tunnel directional exit signs specified in section 13.4d).

13.5 Tunnel emergency exit signs and strobe

a) The Tunnel emergency exit signs must be enabled at all times, with no control from the PMCS.

b) The PMCS must provide manual and automatic control of the Tunnel emergency exit strobes.

c) The PMCS must provide the following automatic control of the Tunnel emergency exit strobes:

i) energise all Tunnel emergency exit strobes in the incident Tunnel when a Tunnel evacuation is initiated, either by STREAMS or by SCADA;

ii) energise the Tunnel emergency exit strobes in the non incident Tunnel at the first cross passageway upstream of the operator declared incident location; and

iii) de-energise all Tunnel emergency exit strobes when a Tunnel evacuation is cancelled, either by STREAMS or by SCADA.

d) The first cross passageway upstream of the operator declared incident location referred to in section 13.5c)ii) is defined as the last cross passageway prior to the incident location when travelling in the direction of traffic in the incident Tunnel.

e) The SCADA subsystem must provide the following manual controls for the PMCS subsystem:

i) energise an individual Tunnel emergency exit strobe;

ii) de-energise an individual Tunnel emergency exit strobe;

iii) energise all Tunnel emergency exit strobes in one Tunnel; and

iv) de-energise all Tunnel emergency exit strobes in one Tunnel.

13.6 Egress passageway alcove lighting

a) The PMCS must provide manual and automatic control of the egress passageway alcove lighting.

b) The PMCS must provide the following automatic control of the egress passageway alcove lighting:

i) energise all egress passageway alcove lighting (in both Tunnels) when a Tunnel evacuation is initiated, either by STREAMS or by SCADA; and

ii) de-energise all egress passageway alcove lighting when a Tunnel evacuation is cancelled, either by STREAMS or by SCADA.

c) The SCADA subsystem must provide the following manual controls for the PMCS subsystem:

i) energise an individual egress passageway alcove lighting;

ii) de-energise an individual egress passageway alcove lighting;

iii) energise all egress passageway alcove lighting in one Tunnel; and

iv) de-energise all egress passageway alcove lighting in one Tunnel.

13.7 Low level emergency luminaires

a) The PMCS must provide manual and automatic control of the low level emergency luminaires.

b) The PMCS must provide the following automatic control of the low level emergency luminaires:

i) energise all low level emergency luminaires (in both Tunnels) when a Tunnel evacuation is initiated, either by STREAMS or by SCADA; and

ii) de-energise all low level emergency luminaires when a Tunnel evacuation is cancelled, either by STREAMS or by SCADA.

c) The SCADA subsystem must provide the following manual controls for the PMCS subsystem:

i) energise all low level emergency luminaires in one Tunnel; and

ii) de-energise all low level emergency luminaires in one Tunnel.

13.8 Low level egress guidance lighting

a) The PMCS must provide manual and automatic control of the low level egress guidance lighting.

b) The in-Tunnel low level egress guidance lighting must be grouped based on each approach to a cross passage or an egress passageway directly accessible from a tunnel carriageway, creating 4 low level egress guidance lighting groups per cross passage or 2 low level egress guidance lighting groups for other egress passageways.

c) All in-Tunnel low level egress guidance lights located in the same egress passageway must be a group.

d) The PMCS must provide the following automatic control of the low level egress guidance lighting:

   i) enable all low level egress guidance lighting groups in the incident Tunnel when a Tunnel evacuation is initiated either by STREAMS or by SCADA;

   ii) enable all low level egress guidance lighting groups in each egress passageway when a Tunnel evacuation is initiated either by STREAMS or by SCADA; and

   iii) disable all low level egress guidance lighting when a Tunnel evacuation is cancelled, either by STREAMS or by SCADA.

e) When an in-Tunnel low level egress guidance lighting group is enabled, the group must operate based on the following sequence:

   i) initially, all guidance lights in a group are energised; then

   ii) starting with the furthermost light in the group from the egress passageway entry, one light must turn off for a user-configurable period of time, then turn back on;

   iii) the next furthermost light in the group from the egress passageway must then turn off for the same configurable period of time, then turn back on;

   iv) this must continue for all lights in the group until the guidance light closest to the egress passageway turns back on;

   v) the cycle must then repeat starting with the furthermost light in the group; and

   vi) the “off time” must be user configurable from SCADA and must be the same time used for all in-Tunnel low level egress guidance lighting groups.

f) When an egress passageway low level egress guidance lighting group is enabled, the group must operate based on the following sequence:

   i) initially, all guidance lights in a group are energised; then

   ii) starting with the light in the group furthest from the non-incident Tunnel, one light must turn off for a user-configurable period of time, then turn back on;

   iii) the next furthermost light in the group from the non-incident Tunnel must then turn off for the same configurable period of time, then turn back on;

   iv) this must continue for all lights in the group until the guidance light closest to the non-incident Tunnel turns back on;

   v) the cycle must then repeat starting with the furthermost light in the group; and

   vi) the “off time” must be user configurable from SCADA and must be the same time used for all egress passageway low level egress guidance lighting groups.

g) The SCADA subsystem must provide the following manual controls for the PMCS subsystem:

   i) enable an individual in-Tunnel low level egress guidance lighting group;

   ii) disable an individual in-Tunnel low level egress guidance lighting group;

   iii) enable an individual egress passageway low level egress guidance lighting group;

   iv) disable an individual egress passageway low level egress guidance lighting group;

   v) enable all in-Tunnel low level egress guidance lighting groups in one Tunnel;

vi) disable all in-Tunnel low level egress guidance lighting groups in one Tunnel;

vii) enable all egress passageway low level egress guidance lighting groups; and

viii) disable all egress passageway low level egress guidance lighting groups.

14 Tunnel fire detection and suppression systems PMCS functional requirements

14.1 General

a) The PMCS must coordinate monitoring and control functions relating to fire safety to enable a coordinated system response to the detection and suppression of fire events in the Tunnels.

b) Through the PMCS-STREAMS interface, the PMCS PLC must provide fire detection status information and enable operator commands to be enacted for fire suppression devices.

c) The PMCS-FCS interface must enable the exchange of fire detection device status to be coordinated between the PMCS and FCS by providing fire alarms originating in either system to the other system.

14.2 Fire detection and suppression functional requirements

a) The status of the following fire related devices must be displayed on SCADA using a graphical layout representative of their location in the Tunnels:

i) activated deluge zones;

ii) PMCS deluge solenoid valve outputs;

iii) FCS deluge solenoid valve outputs;

iv) PMCS controlled fire related valves;

v) FCS controlled fire related valves;

vi) PMCS monitored manual valves;

vii) FCS monitored manual valves;

viii) instrumentation monitored by FCS;

ix) fire related instrumentation monitored by PMCS;

x) deluge pumps;

xi) hydrant pumps;

xii) LHD zone alarms;

xiii) LHD zone temperatures (per deluge zone); and

xiv) LHD fault and status indications.

b) Alarms from the FCS must be handled in accordance with section 3.3.8 and section 3.3.9.

c) Events from the FCS must be handled in accordance with section 3.3.10.

d) Data from the LHD zone temperatures must be used by the PMCS to determine for each Tunnel and display on SCADA the following:

i) average temperature;

ii) maximum temperature; and

iii) minimum temperature.

e) SCADA must provide facility for the operator to initiate operation of each deluge zone.

f) When fire mode is activated, the PMCS PLC must:

i) update the current mode of operation indicated to the FCS;

ii) command the FCS to start the deluge pumps; and

iii) command the FCS to start the hydrant pumps.

g) When a deluge zone is activated, the PMCS PLC must:

i) activate the deluge zone solenoid valve for the selected zone and adjacent zones in accordance with the Fire Engineering design; and

ii) command the FCS to enable its deluge zone solenoid valve for the selected zone.

h) The PMCS must continually calculate and display on SCADA and the FCS the available fire water based on current tank levels and state of the valves.

i) When a fire alarm based on the LHD alarm from the FCS is acknowledged by the operator in either STREAMS or SCADA the PMCS must indicate the fire alarm has been acknowledged.

15 Tunnel closure systems PMCS functional requirements

15.1 General

a) The PMCS must have interfaces to the following Tunnel closure systems (TCS):

i) the TCS located on motorway prior to the Tunnel entry portal;

ii) TCS located on entry ramps that connects to the motorway downstream of the TCS identified in section 15.1a)i); and

iii) as required by the Contract Documents.

b) The PMCS must include automatic and manual controls for each TCS.

c) When a TCS is under the control of the PMCS, the PMCS must provide indication to STREAMS.

15.2 Automated TCS closure

When a PMCS Tunnel closure response plan as defined in section 7.2 is activated, the PMCS must command the TCS identified in section 15.1a) to close in accordance with TUN-ITS-DC2 “Tunnel Closure Systems”.

15.3 TCS manual controls

Whilst the PMCS Tunnel closure response plan as defined in section 7.2 is active, the operator must have the following manual controls for each emergency closure barrier boom arm when the red aspects are active on the adjacent traffic signals:

a) open an emergency closure barrier boom arm; and

b) close an emergency closure barrier boom arm.

16 Tunnel voice communication systems PMCS functional requirements

16.1 General

a) The PMCS must monitor and control the PA system.

b) The PMCS must monitor and control the RRB system.

c) The PMCS must coordinate the broadcast of PA and RRB messages to prevent concurrent broadcasting.

16.2 Public address

a) The PMCS must provide manual and automatic control of the PA system.

b) The PMCS must provide the following automatic control of the PA system:

i) command the PA system to play pre-recorded PA messages in the nominated zones in accordance with an active PMCS response plan; and

ii) command the PA system to play pre-recorded PA messages in the nominated zones in response to a STREAMS command.

c) The SCADA subsystem must provide the following manual controls for the PMCS:

i) select and command the PA system to play a pre-recorded PA message in the selected zones;

ii) select and command the PA system to play a pre-recorded PA message in the selected zones in a loop with a user-configurable delay between each broadcast;

iii) select and command the PA system to play a sequence of pre-recorded PA messages in the selected zones; and

iv) select and command the PA system to play a sequence of pre-recorded PA messages in the selected zones in a loop with a user-configurable delay between each broadcast.

16.3 Radio rebroadcast

a) The PMCS must provide manual and automatic control of the RRB system.

b) The PMCS must provide the following automatic control of the RRB system:

i) command the RRB system to play pre-recorded RRB messages in the nominated Tunnels in accordance with an active PMCS response plan; and

ii) command the RRB system to play pre-recorded RRB messages in the nominated Tunnels in response to a STREAMS command.

c) The SCADA subsystem must provide the following manual controls for the PMCS:

i) select and command the RRB system to play a pre-recorded RRB message in the selected Tunnels;

ii) select and command the RRB system to play a pre-recorded RRB message in the selected Tunnels in a loop with a user-configurable delay between each broadcast;

iii) select and command the RRB system to play a sequence of pre-recorded RRB messages in the selected Tunnels; and

iv) select and command the RRB system to play a sequence of pre-recorded RRB messages in the selected Tunnels in a loop with a user-configurable delay between each broadcast.

17 Wayfinding and positioning PMCS functional requirements

a) There must be an interface between the PMCS and the Tunnel wayfinding and positioning system.

b) The PMCS must be capable of controlling and monitoring the Tunnel wayfinding and positioning system.

c) The PMCS must provide facility to enable and disable the in-Tunnel re-broadcasting of GNSS signals.

d) The PMCS must display the current state of the Tunnel wayfinding and positioning system elements in accordance with TUN-ITS-DC1 “Tunnel Wayfinding and Positioning”.

e) An assessment must be undertaken in accordance with section 3.3.8f) to determine if faults reported to the PMCS by the Tunnel wayfinding system in accordance with TUN-ITS-DC1 “Tunnel Wayfinding and Positioning” are to be treated as:

i) alarms which must be handled in accordance with section 3.3.8 and section 3.3.9; or

ii) events which must be handled in accordance with section 3.3.10 by the SCADA subsystem.

18 Electronic signs PMCS functional requirements

18.1 General

a) There must be an interface between the PMCS and the following electronic signs:

i) LUMS located within the Tunnels;

ii) LUMS located at the Tunnel entry portals and the LUMS immediately upstream of the Tunnel entry portals;

iii) VMS located at the Tunnel entry portals and the VMS upstream of the Tunnel entry portals;

iv) Single Line VMS located within the Tunnels; and

v) any other electronic signs as specified in the Contract Documents.

b) The interface required in section 18.1a) must consist of 2 hardwired digital signals, each of which will command the electronic sign to display a pre-defined scene (also known as “messages” in TSI-SP-003 Communications protocol for roadside devices).

c) The PMCS must include manual and automatic control of the electronic signs via the interface required in section 18.1a).

d) The PMCS must monitor and display the status of the electronic signs nominated in 18.1a). on SCADA when they are under the control of the PMCS.

e) When electronic signs are under the control of the PMCS, the PMCS must provide indication to STREAMS.

18.2 Automatic control

a) When a PMCS Tunnel closure response plan defined in section 7.2 is activated, the PMCS must command the relevant electronic signs to display nominated scenes, in accordance with the response plan.

b) When a PMCS Tunnel evacuation response plan defined in section 7.3 is activated, the PMCS must command the relevant electronic signs to display nominated scenes, in accordance with the response plan.

18.3 Manual control

a) The PMCS must provide the following manual controls:

i) enable each interface signal per electronic sign;

ii) disable each interface signal per electronic sign;

iii) enable interface signals for a group of electronic signs;

iv) disable interface signals for a group of electronic signs; and

v) disable all electronic sign interface signals.

b) The grouping identified in section 18.3a) must be as defined by a response plan.

19 Tunnel facilities PMCS functional requirements

19.1 Lighting

a) The PMCS must control the general lighting in the Tunnel facilities in accordance with TUN-FAC-DC1 “Requirements for Tunnel Facilities”.

b) The status of each luminaire forming part of the Tunnel facilities’ general lighting must be displayed on SCADA.

c) The PMCS must provide facility for manual control by an operator using SCADA of the general lighting of each of the Tunnel facilities required by section 19.1a).

d) SCADA must provide facility to control the general lighting in each Tunnel equipment room and plant room.

e) The PMCS must raise an alarm in SCADA if the general lighting in a Tunnel equipment room or plant room is energised and motion is not detected by the presence detection sensors within the room within a user-configurable duration.

f) General lighting in a corridor or stairwell must be energised by the PMCS when:

   i) a door allowing entry to that area is opened; or

   ii) movement is detected by presence detection sensors in that area.

19.2 Door monitoring

a) The PMCS must monitor all Tunnel facility access doors to and raise an alarm in SCADA when a door is opened.

b) If a perimeter door is detected as being opened for a user-configurable duration the PMCS must raise and alarm in SCADA.

19.3 Air conditioning

a) Where air conditioning has been provided for Tunnel facilities, the PMCS PLC must monitor and display on SCADA the status of the air conditioning systems.

b) An alarm must be generated in SCADA in the event that an air conditioning system has failed.

c) The temperature of Tunnel facilities fitted with air conditioning must be monitored by the PMCS PLC via an independent instrument and current value displayed on SCADA.

d) The humidity of Tunnel facilities fitted with air conditioning must be monitored by the PMCS PLC via an independent instrument and current value displayed on SCADA.

e) An alarm must be generated in SCADA if the temperature within a Tunnel facility is outside of user-configurable:

   i) upper temperature value; and

   ii) lower temperature value.

19.4 Mechanical ventilation

a) Where mechanical ventilation has been provided for above ground Tunnel facilities, the PMCS PLC must monitor the following and display their status on SCADA:

   i) mechanical ventilation fans; and

   ii) mechanical ventilation dampers.

b) The PMCS PLC must implement the control functionality in accordance with the ventilation system design for ventilation of above ground Tunnel facilities.

c) The PMCS must provide facility for manual control by an operator of each of the Tunnel facilities' mechanical ventilation fans and dampers.

d) Tunnel facilities' mechanical ventilation fans and dampers operated automatically or manually by operators must have their status displayed in SCADA.

20 Emergency lighting monitoring

a) The PMCS must provide an emergency lighting maintenance and management system.

b) The emergency lighting maintenance and management system must provide automatic testing and monitoring of egress and emergency lighting detailed in:

   i) TUN-FAC-DC1 "Requirements for Tunnel Facilities"; and

   ii) TUN-FIRE-DC2 "Tunnel Evacuation Systems".

c) Emergency lighting maintenance and management system must incorporate the "Automatic testing and monitoring facilities" functionality defined in TUN-FAC-DC1 "Requirements for Tunnel Facilities".

21 Training and simulation platform

A training and simulation platform must be provided in accordance with the Contract Documents.

22 Reliability, Design Life, and functional safety requirements

a) The PMCS must be designed and provided to comply with the systems engineering requirements and the analysis for reliability, availability, maintainability and safety (RAMS) in accordance with PC-EDM6 "Systems Engineering Management".

b) Where the systems safety activities undertaken in accordance with PC-EDM6 "Systems Engineering Management" result in a SIL being allocated to a PMCS function:

   i) then the relevant parts of the PMCS must be designed, constructed, and delivered in accordance with AS61508 Functional safety of electrical/electronic/programmable electronic safety-related systems; and

   ii) those functions must be implemented independent of the other PMCS functions or demonstrated to be sufficiently independent so as to not be adversely affected by a malfunction of one or more other PMCS functions.

23 Maintainability

a) Redundant PMCS components must be replaceable without disruption to PMCS functions.

b) Traffic management must not be required to gain access to the following equipment:

   i) PMCS PLC CPU racks;

   ii) SCADA servers;

   iii) PMCS communication data network Layer 3 Ethernet switches; or

   iv) firewall cluster forming a gateway to the PMCS field network.

24 Verification requirements and records

24.1 General

a) Testing and commissioning procedures and documentation must be in accordance with the requirements of:

   i) PC-CN1 “Testing and Commissioning”; and

   ii) all system component manufacturer and supplier recommendations.

b) The verification requirements specified in the Master Specification for systems that interface to the PMCS must include the verification of the PMCS functions that control and monitor those systems.

c) PMCS performance requirements must be tested with the PMCS heavily loaded under conditions that could reasonably be expected during fire and evacuation scenarios including:

   i) multiple alarms resulting from congested and stopped traffic conditions;

   ii) multiple alarms from smoke and fire detection;

   iii) implementation of smoke management ventilation control; and

   iv) implementation of response plans including;

      A. Tunnel closure response plans; and

      B. Tunnel evacuation response plans.

d) In addition to the requirements for specified in PC-CN1 “Testing and Commissioning” the following requirements are applicable for FAT relating to the PMCS and its subsystems:

   i) each PMCS sub system must be demonstrated to operate correctly and satisfy allocated requirements as far as practicable in FAT;

   ii) the FAT environment must emulate the installed environment as far as practicable; and

   iii) the FAT environment must include an example of each field device type that will be connected to the subsystem under test.

e) In addition to the requirements for specified in PC-CN1 “Testing and Commissioning” the following requirements are applicable for FIAT relating to the PMCS and its subsystems:

   i) each PMCS interface must be demonstrated to operate correctly and satisfy allocated requirements as far as practicable in FIAT;

   ii) the FIAT environment must emulate the installed environment as far as practicable, including:

      A. the network over which the data is exchanged;

      B. the PMCS PLC system configuration; and

      C. the subsystem configuration; and

   iii) each PMCS interface must be demonstrated to operate correctly in FIAT with the associated network being heavily loaded.

f) In addition to the requirements for specified in PC-CN1 “Testing and Commissioning” the following requirements are applicable for SAT relating to the PMCS and its subsystems:

   i) each PMCS sub system must be demonstrated to operate correctly in the installed environment in their final configuration; and

   ii) the SAT must demonstrate correct operation of all PMCS components, for clarity, sample testing is not allowed.

g) In addition to the requirements for specified in PC-CN1 “Testing and Commissioning” the following requirements are applicable for SIAT relating to the PMCS and its subsystems

i) each PMCS interface must be demonstrated to operate correctly and satisfy allocated requirements in the installed environment with all systems in their final configuration, including:

A. the network over which the data is exchanged;

B. the PMCS PLC system configuration; and

C. the subsystem configuration;

ii) each PMCS interface must be demonstrated to operate correctly in SIAT with the associated network being heavily loaded; and

iii) each data point used for control or monitoring of a field device exchanged over the interface must be demonstrated to operate correctly from the field device through to the PMCS PLC system.

24.2 PMCS resilience testing

a) The testing and commissioning activities for the PMCS must include activities to demonstrate the resilience of the PMCS, including:

i) the ability to restart and return to normal operation from total power loss without intervention;

ii) failover from primary PMCS PLC to secondary PMCS PLC upon:

A. loss of communications to primary PMCS PLC;

B. loss of power to the primary PMCS PLC; and

C. primary PMCS PLC being taken out of run mode;

iii) failover from primary SCADA server to secondary SCADA server upon:

A. loss of communications to primary SCADA server;

B. loss of power to the primary SCADA server; and

C. primary SCADA server being taken out of service;

iv) the ability for the PMCS PLC system to continue to perform the following functions in the event a PMCS data communication network device becoming unavailable:

A. maintain PMCS PLC functions;

B. communicate with all PLC remote I/O racks;

C. read / write data to SCADA; and

D. maintain interfaces to other subsystems; and

v) the testing activities required by 24.2a)iv) must be conducted for each PMCS data communication network device in the SIAT environment.

b) Where voting or value averaging function requirements are defined for redundant field devices then the testing and commissioning activities must include activities to demonstrate correct operation of these functions for all credible degradation conditions that may exist.

c) Where power to PMCS equipment is fed from multiple electrical supplies, the testing and commissioning activities must include activities to demonstrate the continued correct operation of the PMCS equipment upon:

i) transition to alternate electrical supply;

ii) loss of a single electrical supply; and

iii) restoration of an electrical supply.

25 Appendix 1

Table TUN-PMCS-DC1 25-1 provides high level guidance on the data points the Principal expects will be exchanged over the interface between the PMCS PLC and STREAMS by reference to the control functions and monitoring functions (status, measurement, health, fault and availability) the Principal expects will be available in the SCADA and STREAMS.

Table TUN-PMCS-DC1 25-1 PMCS PLC STREAMS data point guidance

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
Tunnel carriageway ventilation	Control	Jet fan control	Yes	Yes	
	Status	Jet fan status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring – detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Exit portal ventilation station outlets	Control	Axial fan control	Yes	Yes	
	Control	Damper control	Yes	No	
	Status	Axial fan status	Yes	Yes	
	Status	Damper status	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Egress passageway pressurisation	Control	Pressurisation fan control	Yes	Yes	
	Control	Damper control	Yes	Yes	
	Status	Pressurisation fan status	Yes	Yes	
	Status	Damper status	Yes	Yes	
	Measurement	Measurement monitoring	Yes	Yes	Egress passageway pressure differentials (time averaged)
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Tunnel sump ventilation	Control	Sump fan control	Yes	Yes	
	Control	Damper control	Yes	Yes	
	Status	Sump fan status	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Status	Damper status	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Service tunnel ventilation	Control	Service tunnel fan control	Yes	Yes	
	Control	Damper control	Yes	Yes	
	Status	Service tunnel fan status	Yes	Yes	
	Status	Damper status	Yes	Yes	
	Measurement	Measurement monitoring	Yes	No	If service tunnel conditions are monitored (humidity, temperature) to control ventilation
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Ambient air monitoring	Measurement	Measurement monitoring	Yes	No	
	Measurement	Time averaged Measurement monitoring	Yes	Yes	Time averaged measurements suitable for operator monitoring
	Status	Status monitoring	Yes	Yes	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Tunnel carriageway air monitoring	Measurement	Measurement monitoring	Yes	No	
	Measurement	Time averaged Measurement monitoring	Yes	Yes	Time averaged measurements suitable for operator monitoring
	Status	Status monitoring	Yes	Yes	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Availability	In-service / out of service / unavailable	Yes	Yes	
Ventilation station air monitoring	Measurement	Measurement monitoring	Yes	No	
	Measurement	Time averaged Measurement monitoring	Yes	Yes	
	Status	Status monitoring	Yes	Yes	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Fire control system	Control	Control	Not applicable	Not applicable	
	Status	Status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Not applicable	Not applicable	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Fire detection	Control	Control	Not applicable	Not applicable	
	Status	Status monitoring	Yes	Yes	
	Status	Smoke detected	Yes	Yes	
	Status	Linear thermal detector status monitoring	Yes	Yes	
	Measurement	Linear thermal detector temperature / location	Yes	No	
	Measurement	Linear thermal detector fire in zone detected	Yes	Yes	Detection of fire in a zone (e.g. deluge zone)
	Health	Linear thermal detector Health monitoring	Yes	No	e.g. self calibration results
	Health	VEWASD Health monitoring	Yes	No	e.g. self calibration results
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Fire suppression	Control	Deluge / misting control	Yes	Yes	
	Control	Isolation valve control	Yes	Yes	
	Status	Deluge / misting status monitoring	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Status	Isolation valve status monitoring	Yes	Yes	
	Status	Hydraulic pump status monitoring	Yes	Yes	
	Status	Building sprinkler system status monitoring	Yes	Yes	
	Status	Gaseous suppression system status monitoring	Yes	Yes	
	Status	Emergency equipment cabinet status monitoring	Yes	Yes	
	Status	Hydrant cabinet status monitoring	Yes	Yes	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Tunnel power system	Control	Tunnel power system control functions	Yes	No	
	Status	Tunnel power system status monitoring	Yes	Yes	
	Measurement	Power usage measurement	Yes	Yes	Only a subset / summary of measurements required to be made available on STREAMS
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Tunnel lighting and underpass lighting	Control	Lighting level control	Yes	Yes	
	Control	Individual luminaire control	Yes	No	
	Status	Lighting level status monitoring	Yes	Yes	
	Status	Individual luminaire status monitoring	Yes	No	
	Measurement	Tunnel luminance measurements	Yes	No	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Availability	In-service / out of service / unavailable	Yes	Yes	
Building services lighting	Control	Facility lighting control	Yes	Yes	STREAMS control of lighting in all locations not required
	Status	Facility lighting status monitoring	Yes	Yes	STREAMS monitoring of lighting status in all locations not required
	Status	Occupancy detection sensors status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Evacuation systems	Control	Evacuation system control functions	Yes	Yes	
	Status	Evacuation system status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Heat, ventilation and air conditioning	Control	HVAC control functions	Yes	No	
	Status	HVAC general status	Yes	No	
	Status	Temperature set points exceeded	Yes	Yes	
	Measurement	Measurement monitoring	Yes	No	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Drainage systems	Control	Pump control functions	Yes	Yes	
	Control	Isolation valve control functions	Yes	Yes	If remove control of isolation valves available

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Status	Pump status monitoring	Yes	Yes	
	Status	Isolation valve status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Yes	Yes	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Ground water monitoring and recharge	Control	Pump control functions	Yes	No	
	Control	Isolation valve control functions	Yes	No	
	Status	Pump status monitoring	Yes	No	
	Status	Isolation valve status monitoring	Yes	No	
	Status	Setpoint exceedance	Yes	Yes	
	Measurement	Measurement monitoring	Yes	No	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Water treatment	Control	Control functions	Yes	No	
	Status	Status monitoring	Yes	No	
	Status	Environmental setpoint exceedance	Yes	Yes	
	Measurement	Measurement monitoring	Yes	No	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Voice communication	Control	Control functions	Yes	Yes	
	Status	Status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Yes	No	Automated self check results
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment
	Availability	In-service / out of service / unavailable	Yes	Yes	
Lowered motorway sumps and pumps	Control	Pump control functions	Yes	Yes	
	Control	Isolation valve control functions	Yes	Yes	If remove control of isolation valves available
	Status	Pump status monitoring	Yes	Yes	
	Status	Isolation valve status monitoring	Yes	Yes	
	Status	Setpoint exceedance	Yes	Yes	
	Measurement	Measurement monitoring	Yes	Yes	Levels and inflows
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
Tunnel equipment cabinets	Control	Control functions	Not applicable	Not applicable	
	Status	Tunnel equipment cabinet status	Yes	Yes	Door open alarms, temperature set point exceedance, active cooling status
	Measurement	Measurement monitoring	Not applicable	Not applicable	
	Health	Health monitoring	Not applicable	Not applicable	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major /warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	
In tunnel positioning	Control	Control functions	Yes	Yes	Activate / deactivate
	Status	Status monitoring	Yes	Yes	
	Measurement	Measurement monitoring	Yes	No	
	Health	Health monitoring	Yes	No	
	Fault	Fault monitoring - detailed	Yes	No	
	Fault	Fault monitoring - major / warnings	Yes	Yes	
	Availability	In-service / out of service / unavailable	Yes	Yes	

System	Data point type[1][2][3][4][5][6]	Supported function[7][8]	Available in SCADA	Available in STREAMS	Comment

Table notes:

(1) **Control:** data points type required to support the control of devices (e.g. stop, start, on, off, open, closed, forward, reverse, overrides, speed, activate, deactivate, setting setpoints).

(2) **Status:** data points used to monitor the status of devices (e.g. on, off, open, closed, forward, reverse, standby, speed, activated, deactivated, detection of an event).

(3) **Measurement:** data points used to pass measurements used operationally (e.g. air velocity, flow, temperature, pressure, water level, CO, CO^2, visibility, light levels, calculated values, averaged values, inferred values).

(4) **Health:** data points used to pass information on the health of a device for maintenance and asset management purposes (e.g. vibration, temperature, current, voltage, luminance, calibration results, maintenance event due, consumable replacement due).

(5) **Fault:** data points used to pass information on device faults (e.g. that may or may affect availability, performance, functionality).

(6) **Availability:** data points used to describe the availability of a device (e.g. in-service, out of service, unavailable).

(7) **Fault monitoring - detailed:** specific faults reported for a device.

(8) **Fault monitoring - major / warnings:** faults that impact availability, performance, or functionality or may adversely affect the availability, performance or functionality of other systems and may have an operational impact.