

Annexure 1.4:
General Technical Requirements
Telecommunications

Contents

1	GENERAL	4
1.1	Purpose of the Document	4
1.2	Executive Overview	4
2	MINIMUM SYSTEM REQUIREMENTS	5
2.1	Telecommunications System (“TS”) Overview	5
2.2	Optical Transmission Network (“OTN”)	6
2.3	Optical Fibre Cable System	9
2.4	Patch panels	14
2.5	Electrical Remote Monitoring and Control System (“Telecontrol”)	14
2.6	Telephone System for Operational applications	21
2.7	Global Positioning System (“GPS”) - Time Distribution System	25
2.8	Asset Protection	26
3	ENGINEERING	35
3.1	Design and Build Risk Assessment	35
3.2	Process Model	35
4	CONSTRUCTION	42
4.1	General	42
5	TESTING AND COMMISSIONING	43
5.1	General	43
5.2	Factory Acceptance Testing (“FAT”)	43
5.3	Site Acceptance Testing (“SAT”)	44
5.4	Final Testing and Commissioning	45
6	DECOMMISSIONING, DISMANTLING AND REMOVAL	46
6.1	General	46
7	MAINTENANCE	47
7.1	Overview	47

	7.2	First Level Maintenance	48
	7.3	Second Level Maintenance	49
	7.4	Third Level Maintenance	49
	7.5	Fourth Level Maintenance	50
8		WARRANTIES	52
	8.1	General	52

1 GENERAL

1.1 Purpose of the Document

- 1.1.1 The purpose of this document is to provide the General Technical Requirements (“GTR”) which form part of the minimum Requirements of the Passenger Rail Agency of South Africa (“PRASA”) for the Telecommunications related Works that form part of the planning, design, supply, construction, installation, testing, commissioning and maintenance of a new fully integrated, functional, complete and future-proofed PRASA Train Control System (“PTCS”) in PRASA’s KwaZulu-Natal (“KZN”) service region (“the Project”) that the Bidder shall meet and deliver at the Bidder’s cost therefore within the Bid Price.

1.2 Executive Overview

- 1.2.1 Notwithstanding any other PRASA Requirements stated throughout the RFP, the Bidder shall uncompromisingly deliver the whole of the Works required to achieve successful delivery of the Project.
- 1.2.2 The Telecommunications Component of the Works is, at a minimum, summarised as follows:
- a) Provide an Optical Transmission Network (“OTN”) to be used for at least interlocking Signalling remote monitoring and controls, tractions substations remote control and monitoring, telephone Systems, security surveillance System, access control and passenger information Systems
 - b) Provide an Electrical Remote Monitoring and Control System (“Telecontrol”) that complies with PRASA requirements
 - c) Provide a Telephone System for Operational Applications that complies with PRASA requirements
 - d) Provide a GPS time distribution System that complies with PRASA requirements
 - e) Provide an Asset Protection System that complies with PRASA requirements
 - f) Provide Telecommunication Equipment Rooms that complies with PRASA requirements
 - g) Provide all necessary telecommunications requirements at the Central Train Control Center (“CTCC”)
 - h) Any other Signalling Works, activities and resources required to achieve a fully integrated, functional, complete and future-proofed PTCS and meet any other requirements and specifications as requested throughout the RFP or as otherwise instructed in writing by PRASA.

2 MINIMUM SYSTEM REQUIREMENTS

2.1 Telecommunications System (“TS”) Overview

- 2.1.1 The Telecommunications System (“TS”) shall, at a minimum, consist of the following elements:
- a) Optical Transmission Network.
 - b) Electrical Remote Monitoring and Control System.
 - c) Telephone System for Operational Applications.
 - d) GPS Time distribution System.
 - e) Asset protection.
 - f) Telecommunication Equipment Rooms.
 - g) Service and Diagnostic System (“S&D”).
- 2.1.2 The TS shall, at a minimum, comply with all relevant Standards, Specifications, Regulations and Procedures as specified throughout the RFP.
- 2.1.3 The TS shall be Designed to have very limited exposure to theft and vandalism and shall have no or very limited copper (if the limited copper has zero value in any second-hand market).
- 2.1.4 The Bidder shall implement all necessary measures to protect the Telecommunications System, sub-Systems and all Equipment against at least the following threats:
- a) Theft and vandalism.
 - b) Continues exposure to extreme direct sunlight and elevated temperatures.
 - c) Continues exposure to high humidity.
 - d) Coastal environmental conditions causing damaged such as corrosion.
 - e) Incoming high voltages, spikes, Electromagnetic Compatibility (“EMC”) and fluctuating voltages.
 - f) Intermittent flash flooding in low laying areas.
 - g) Severe thunderstorms with extreme heavy lightning.
- 2.1.5 Reliability:
- a) The Bidder shall provide the predicted mean time to failure
 - b) The mean time to repair of the Equipment shall be less than 3 hours during peak periods (05h00-09h00 and 14h00-19h00) including travel time and less than 4 hours for off-peak periods including travel time.
 - c) Where insufficient historical data is available, the Bidder shall state the methods used to determine the reliability performance.

- d) The Telecommunications System Component's availability shall be 99.999% as a minimum with the following assumptions:

- The availability of any interconnecting communication Equipment or System supplied by others shall be assumed to be 100%

2.1.6 Equipment life cycle:

- a) The Equipment shall be capable of complying with this standard including performing its intended purpose for a minimum period of 20 years from the date of Supply.
- b) The supplier shall indicate the following:
- The date at which the product was released for sale
 - The anticipated date at which the product shall be withdrawn from sale, but support shall continue to be supplied
 - The anticipated date that product support shall be withdrawn, i.e. Spares shall no longer be available and technical support is no longer provided

2.1.7 Racks and Clearances

- a) All Telecommunications Equipment shall be mounted inside racks on rails.
- b) The minimum rack frame dimensions shall be 600 mm wide and 600 mm deep and provide 42 RU (Rack Unit = 44.45 mm)
- c) A minimum access clearance of at least 1 m shall be maintained on the front and back of racks, where access is required for operations or Maintenance.

2.2 Optical Transmission Network ("OTN")

2.2.1 The transmission System shall be used for at least interlocking Signalling remote monitoring and controls, tractions substations remote control and monitoring, telephone Systems, security surveillance System, access control and passenger information Systems. The Bidder shall therefore analyse the interactions and effects on other applications, including hazards and impact on performance.

2.2.2 The transmission is the complete communication path, which transfers message streams between two applications, including transmission mediums, Equipment, technologies, interfaces and any other items, which contribute to communication.

2.2.3 The OTN System shall, at a minimum, consist of the following elements:

- d) Direct Buried Fibre Optic Cable.
- e) Manholes.
- f) Dome Joints.
- g) Patch Panels.

2.2.4 The Fibre Optic Cable shall be installed in-between Signal Equipment Rooms (“SER”), with dedicated tubes terminating at Ticket Offices, GSM-R Equipment Rooms and 3kV / 6.6kV Substations as illustrated in Figure 2.2.1.

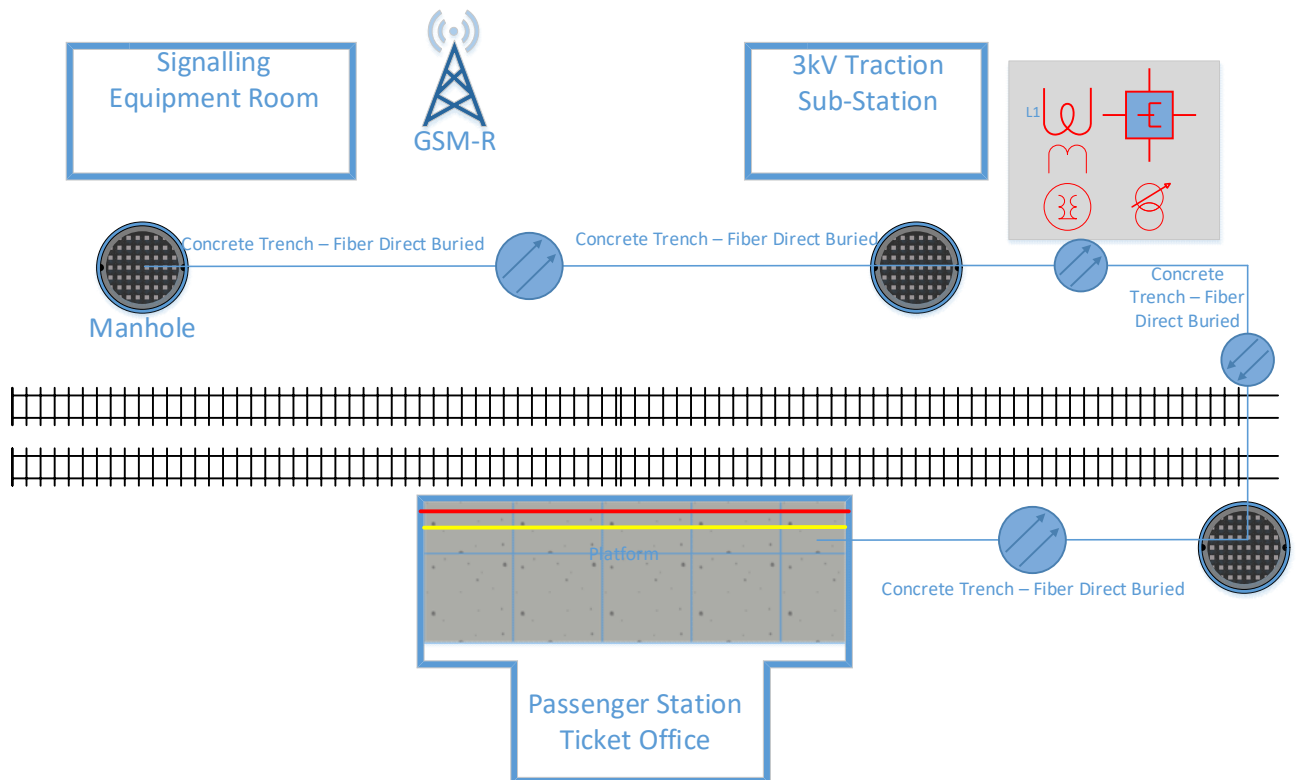


Figure 2.2.1: OTN Applications

2.2.5 Transmission System failure and delays:

- a) The transmission System delay from one application to another application over the complete communication path shall be less than 50ms, excluding the application's processing time but considering (not limited to) the following:
 - Communication path's characteristics
 - Switching to diverse communication path
 - Encryption/decryption
 - Message overheads of the transmission System
 - Routing
 - Retries
 - Jitters
 - Latency

- b) When a transmission medium failure is experienced, the Signalling and control Systems applications communications within each other over the transmission System shall achieve the following if as a minimum:
 - Complete failure criteria of individual message:
 - Redirect on a Redundancy pass
 - Timeliness criteria
 - Message ordering criteria
- c) The maintainability down time (mean time to restore) for the transmission System shall not exceed 1 h on average for each complete communication path.

2.2.6 Transmission System Redundancy requirements:

- a) The transmission System Technology shall comply with the latest MPLS-TP (Multi-Protocol Label Switching transport profile) architecture of the layer Network standard is described in the ITU-T - G.8110.1/Y.1370.1.
- b) The transmission solution shall fully comply with the MPLS-TP Requirements as defined in the referenced IETF standard – RFC 5654, these requirements shall form part of the Factory Acceptance Procedure.
- c) The transmission solution shall comply with the following standards:
 - EN-50126 - for safety-critical communications on railways application
 - EN-50159 (part 1 and 2) - for safe communication in railway closed Networks
 - EN-50128 - Software for Railways Control and Supervision Systems
 - EN-50129 - Safety relevant electronic Systems for Signalling Technology
 - EN-50121-4 – for Emission and immunity of telecommunications apparatus
- d) The transmission solution shall be:
 - Ruggedized – Fan-less with no moving parts
 - Operating in the temperature range -10°C to +75°C
 - Modular with full Components Redundancy capability for all modules in the same rack, all hot pluggable
 - Support PoE (Power over Ethernet) modules for direct IP telephone and IP cameras
 - Support 1G, 10 G and 40 G WAN (Wide Area Network) or LAN (Local Area Network) IP interface modules

- e) In the event of fibre optic communication failure on the first (main) OFC the System shall automatically switch over to the backup communication System, which is the second OFC. If both Systems fail, the communication shall be switched to Isolate only the affected sites whilst the remaining Network is operational using a dual ring feed System. When fibre optic communication is restored the System shall automatically switch back to its default mode based on master and slave modes. This transition of communication between Networks shall be seamless in less than 20ms.
- f) The Bidder shall implement a single full management platform to monitor, operate and manage the fibre transmission Network for both Signalling and Telecommunication installed switches. The platform monitoring and control shall be based on VDU's overview to cater for 24 hours management in compliance with the control centre standards ISO 11064.
- g) The configurations shall be done on a windows 10 GUI based application.

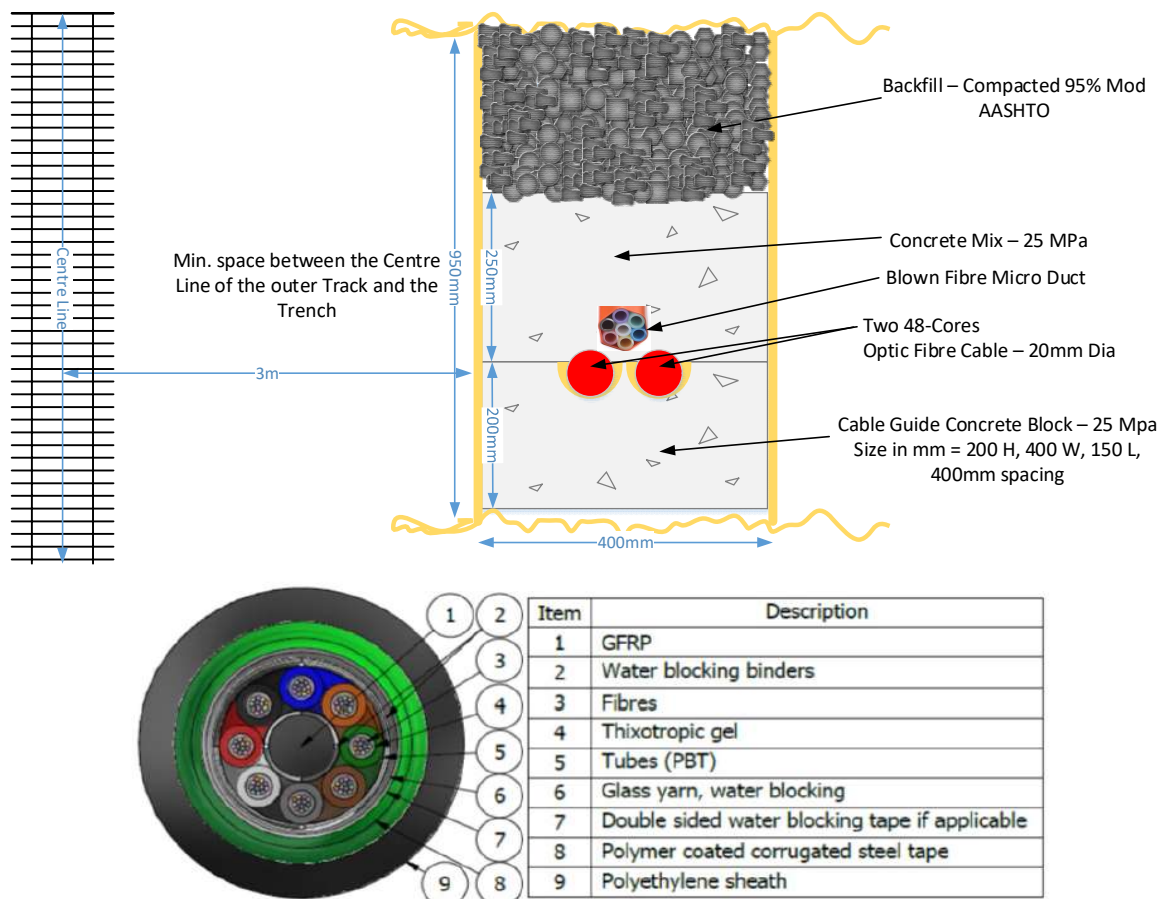
2.3 Optical Fibre Cable System

- 2.3.1 Cable route and cables shall be designed and constructed to provide capacity for both signalling and non-signalling communications services using two 96 core fibre cables.
- 2.3.2 The OTN shall consist of two separate 96 core cables, one dedicated to Signalling Systems, and one dedicated to other business services as shown below:
 - a) OTN-1: Signalling services.
 - b) OTN-2: Business services.
- 2.3.3 The OTN-1-96 Core Cable shall be sub-divided into 2 coloured tubes, 48 cores dedicated per sub-System as shown below:
 - a) Blue Tube – Signalling Equipment Room.
 - b) Brown Tube – GSM-R Sites.
- 2.3.4 The OTN-2-96 Core Cable shall be sub-divided into 4 coloured tubes, 24 cores dedicated per sub-System as shown below:
 - a) Blue Tube – Security Systems.
 - b) Green Tube – Ticket Office Equipment Room (IT Services).
 - c) Orange Tube – 3kV / 6.6kV Traction Sub-Station.
 - d) Brown Tube – Fibre Monitoring and Management Systems.
- 2.3.5 Fibre Optical Cable shall be installed between Manholes with respective termination per sub-System, i.e.:
 - a) The OTN-1-Signalling tube shall terminate at the SER Manhole and Patch Panel.
 - b) The GSM-R tube shall terminate at the GSM-R Equipment Room and Patch Panel.

- c) The 3kV Traction Sub-Station tube shall terminate at the Sub-Station Equipment Room Manhole and Patch Panel.
- d) The Ticket Office tube shall terminate at the Ticket Office Equipment Room Manhole and Patch Panel.
- e) The Security tube shall terminate at all Equipment Rooms.
- f) The Fibre Monitoring and Management System tube shall terminate at the branching sites where all fibre cables are present.

2.3.6 All new fibre installations shall be buried directly in an encased concrete trench to at least 950mm in depth and 400mm wide.

2.3.7 The Fibre Optical Cable ("FOC") shall be raised by at least 200mm from the trench floor using proposed means to balance the cable throughout the trench as shown in



2.3.8 Figure 2.3.1.

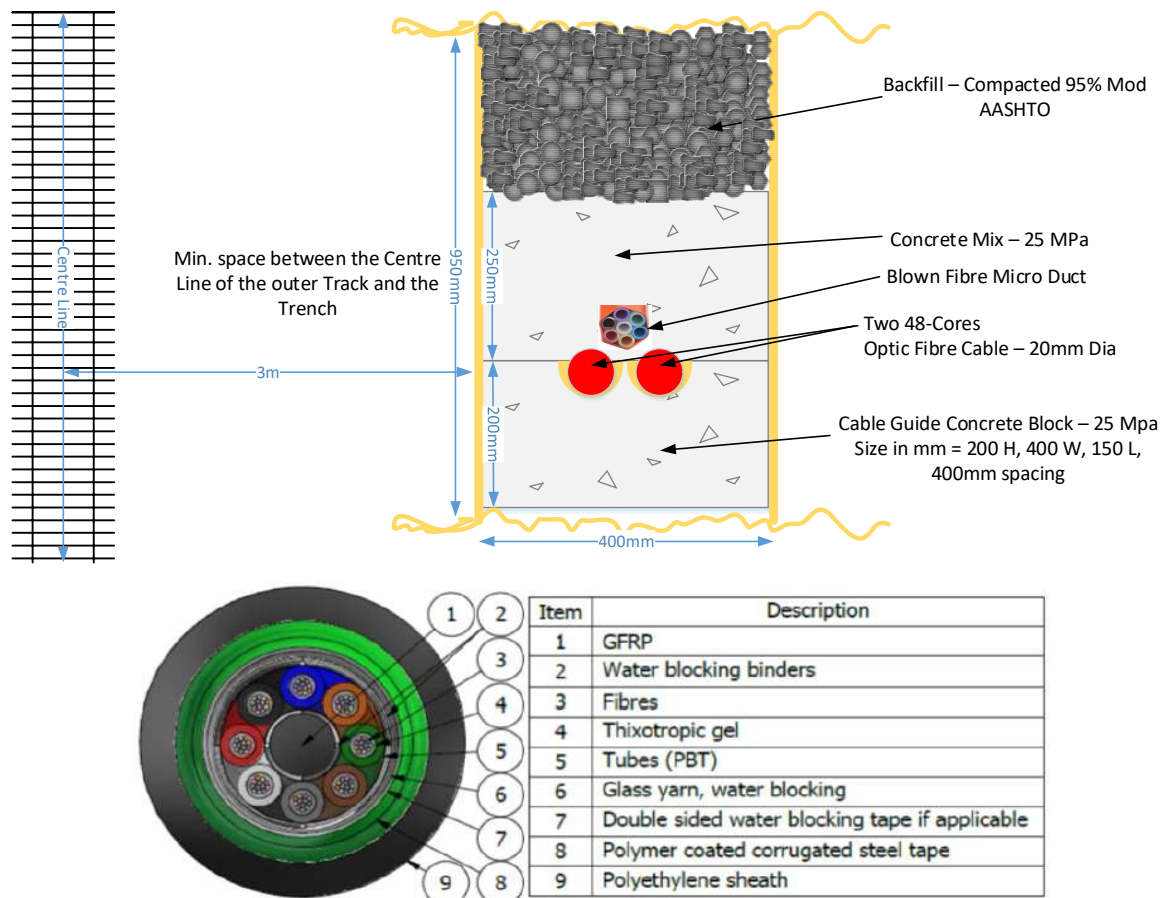
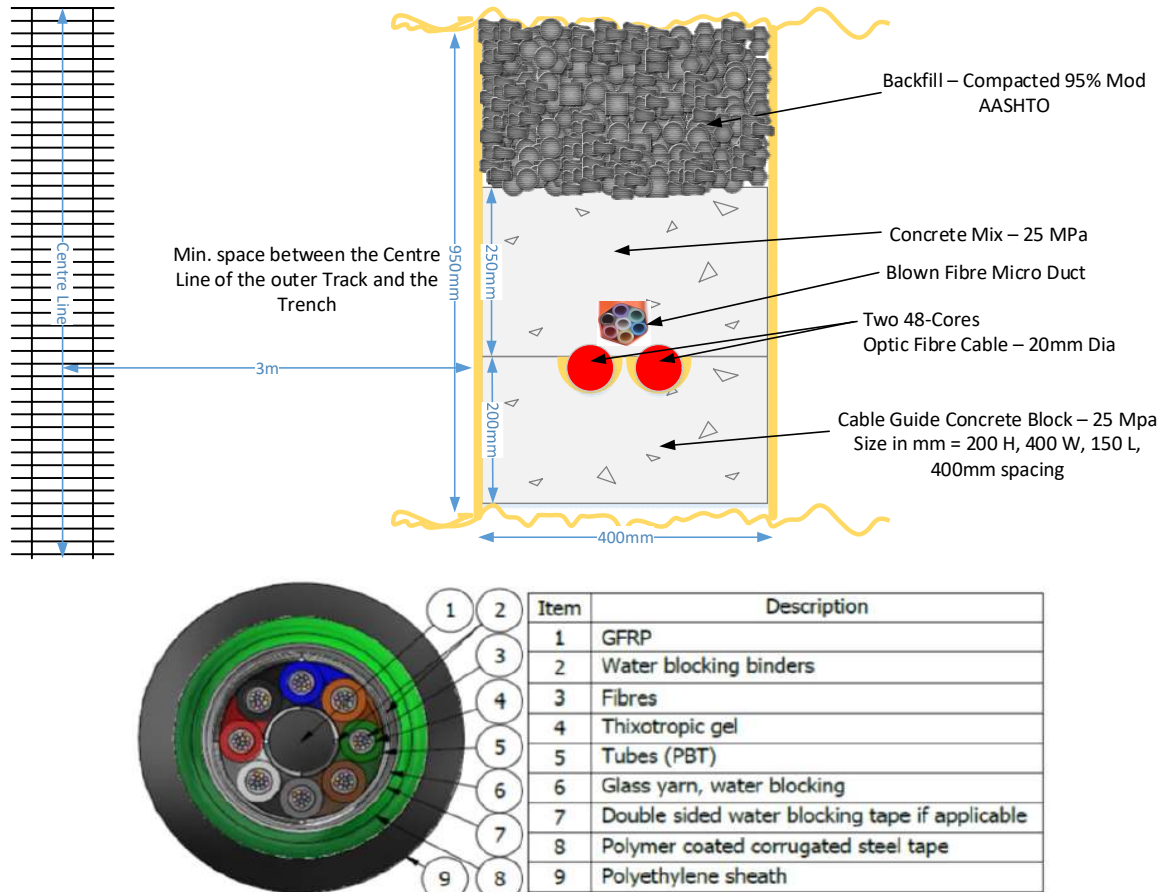


Figure 2.3.1: Underground Optic Fibre Cable Trench Layout

2.3.9 The minimum space between precast cable guidance blocks inside the 400mm wide trench shall be 400mm apart to allow of any manual labour required for pulling of the cable, cable sagging shall be avoided at all times.

2.3.10 A Fibre Optic Duct with a minimum of four-way Microducts shall be installed in the trench is illustrated in



2.3.11 Figure 2.3.1 for Blowing future required Fibre.

2.3.12 Cleaning of the Microduct shall be conducted by means of blowing an appropriately sized sponge through the micro duct, which will also help in removing any accumulated water.

2.3.13 The installed micro ducts shall be tested using a round proofing ball or pellet that is 80% of the size of the Microduct blown through the duct to ensure there is no obstruction in the duct.

2.3.14 The Bidder shall comply with all the relevant Standards, Specifications and implement the early warning underground cable intrusion detection system and ensure the following minimum requirements are defined in detail and met:

a) Mechanical Requirements:

- Sensor cable
- Sensor unit equipment

b) Environment Requirements

c) Reliability and Maintenance Requirements

d) Electrical Requirements

- e) Detection Capabilities
 - f) Network Capabilities
 - g) Event Management
- 2.3.15 The two 96 core single mode optical cables shall comply with the ITU-T G.652.D standard and the following attributes shall be used:
- a) Double Jacket.
 - b) Corrugated Steel Tape Armouring.
- 2.3.16 The single mode optical cable shall provide protection to:
- a) Strain from both cable tension and bending.
 - b) Crush and impact both during installation and operational life.
 - c) Hydrogen gas generated by the presence of moisture and metallic elements.
 - d) Moisture permeation.
 - e) Water penetration.
 - f) Lightning damage.
 - g) Biological attacks.
 - h) Biotic damage.
 - i) Vibrations from railways.
 - j) South African temperature variations.
 - k) Chemical attack.
 - l) Mechanical aggression.
- 2.3.17 A minimum length of 5 metres from each end shall be implemented when splicing takes place inside the manhole.
- 2.3.18 A minimum length of 10 metres shall be achieved when splicing takes place outside the manhole.
- 2.3.19 Inside the manhole, the splice box shall be fixed directly on the wall or using an appropriate support, depending on the box design.
- 2.3.20 The installed manhole shall be:
- a) Corrosion resistant.
 - b) UV resistant.
 - c) Slack management mechanism.
 - d) Impact resistant.
 - e) PRASA branded with a PRASA LOGO.
- 2.3.21 The installed fibre cables shall comply with the following latest standard specifications:

- a) ITU-T G.651.1 - Characteristics of a 50/125 μm multimode graded index optical fibre cable for the optical access Network.
- b) ITU-T G.652 - Characteristics of a single-mode optical fibre and cable [6].
- c) ITU-T G.653 - Characteristics of a dispersion-shifted, single-mode optical fibre and cable.
- d) ITU-T G.654 - Characteristics of a cut-off shifted single-mode optical fibre and cable [8].
- e) ITU-T G.655 - Characteristics of a cut-off shifted single-mode optical fibre and cable.
- f) ITU-T G.657 - Characteristics of a bending-loss insensitive single-mode optical fibre and cable.

2.3.22 The fibre optic cable splicing procedure shall be accordance with the ITU-T standard L.12 - Optical fibre splices.

2.3.23 All splicing shall be Electric arc-fusion method to make reliable optical splices using specially developed splicing machines.

2.4 Patch panels

2.4.1 The Bidder shall provide, at a minimum, the following size patch panels in the Equipment:

- a) Signal Equipment Rooms: 1 x 48 core and 1 x 12 core.
- b) GSM-R Equipment Rooms: 1 x 48 core and 1 x 12 core.
- c) Ticket Offices: 2 x 12 core.
- d) Sub-stations: 2 x 12 core.

2.4.2 The Bidder shall terminate and/or patch through all cores in a specific tube going to a specific Equipment Room.

2.5 Electrical Remote Monitoring and Control System (“Telecontrol”)

2.5.1 The Bidder shall Design and implement a SCADA (Supervisory Control and Data Acquisition) System Solution for PRASA Rail 3kV DC Traction Substations, 11kV and 6.6kV Distribution Substations to interface to standardized industrial remote terminal units suitable for railway harsh conditions.

2.5.2 The Designed Solution Software Application for SCADA System shall be PRASA's full intellectual property, which shall be implemented as a rollout solution in its entirety.

2.5.3 The Electrical SCADA System shall be used to monitor and control PRASA Rail High Voltage (HV) Electrical Supply Networks for 3kV DC traction and 6.6kV / 11kV AC Signalling Substations.

2.5.4 The master stations shall interface with the substations field devices via a communications medium dedicated for railway operation use only.

- 2.5.5 The sub-station field devices also referred to as Remote Terminal Units (“RTUs”) are generally located in Traction Substations and Signalling High Voltage Distribution Substations. These locations contain Equipment such as HV AC circuit breakers, DC circuit breakers, rectifiers, transformers and other miscellaneous Equipment, which requires remote control and management.
- 2.5.6 The current Telecontrol System shall be taken into consideration for newly Designed development of the SCADA System to replace the current Technology without deviating in the user operational rules.
- 2.5.7 Functionality requirements:
- a) The SCADA System shall be Designed for utilization over industrialized IP communications platform for:
 - Remote switching function used for traction substation
 - IED (Intelligent Electronic Devices) transfer trip protection scheme
 - b) The SCADA System shall be Designed to provide control and remote monitoring of the DC and AC railway traction substation devices.
 - c) The Design of the SCADA System shall be centralized with full administration capabilities.
 - d) The Host control functionality shall be controlled and restricted to supervisory logging interventions.
 - e) The SCADA System shall be managed from a common distributed database using tagging for all activities on all soft and hard points.
 - f) All SCADA points shall be stored as value-timestamps tagged in their respective action.
 - g) The SCADA System shall be protected from security vulnerability, in isolation from the business ICT infrastructure used for office emails, SCM Systems and any other database not used for train operation.
- 2.5.8 Remote Terminal Unit Environmental conditions:
- a) The RTU shall be Designed suitable for indoor use and conditions existing in DC and AC railway traction substation.
 - b) RTUs installed indoors shall comply with the ambient temperature range between -5° to +75°C.
 - c) RTUs installed in a rack on overhead wiring structures in the field (outdoors) shall be weathered proofed to comply with the ambient temperature range of -10°C to +65°C and the extremes of outdoor environmental conditions.
 - d) RTUs installed in the coastal areas shall comply with the anticorrosion standards for electronics Equipment installed in the railway environment.
 - e) Heat dissipation calculations shall be provided to demonstrate the RTU’s ability to comply with the temperature ratings of the Equipment in the range specified.

2.5.9 RTU power Supply:

- a) The RTU shall derive its power requirements from the substation battery provided by which supplies essential Equipment in the substation.
- b) The power Supply shall be 110V DC.
- c) In locations where 110V DC power Supply is provided shall be a secure Supply and no other battery backup System is required for the RTU.
- d) The RTU power Supply shall be Designed to operate at full-specified performance for DC supplies conforming to the following requirements:
 - Voltage ripple: not more than 5% of nominal Supply voltage, peak to peak
 - Voltage tolerance: +15%/-20%
- e) The RTU power Supply shall be Designed to operate at fully specified performance for DC Supply earthing condition requirements for DC and AC railway traction substations.
- f) The RTU shall have an inbuilt switched mode power Supply ranging from 80 V AC/DC to 270 V DC/AC input voltage.
- g) The RTU shall have a CMOS (Complementary Metal-Oxide-Semiconductor) battery to power and refresh processor memory in the event of System power failure.

2.5.10 RTU Central Processing Unit ("CPU"):

- a) The RTU shall be microprocessor based. Once power is supplied to the unit, it shall be Designed to operate without manual intervention.
- b) The RTU shall auto restart and be able to communicate with the master station without reporting spurious state changes on power resumption after a power failure.
- c) Suitable reliable indicators such as LEDs shall be provided for personnel to readily ascertain the status of the RTU.
- d) The processor shall monitor the health of the RTU with in-built diagnostics which are capable of remote interrogation including diagnostics for:
 - Memory and bus errors
 - Buffer overflows
 - Local Software routine health
 - Communication ports status
 - Input/output card health
- e) Diagnostics supplied shall permit complete Testing of the RTU with a portable computer.

- f) Diagnostic checking of the communication ports shall be provided to permit checking by a portable computer.
- g) Power Supply and battery low, overvoltage or failure conditions shall be monitored.
- h) The RTU shall possess memory to permit storage of a minimum of 2000 events (input changes) locally for subsequent transmission to the SCADA master station. These events shall not be lost on buffer overflow. An indication shall be provided of this latter condition.
- i) Events shall be retained in the buffer until they are correctly read by the master station. As a minimum separate buffer shall be provided for digital and analogue events.
- j) To enable fault finding, there shall be a separate event list to record internal RTU events such as health, time synchronization and any internal errors. This shall permit storage of up to 2000 events.
- k) When memory is provided for the purposes of local control or communications routines, Spare capacity shall be provided equal to the amount utilized.
- l) The RTU shall have a real time clock with a resolution of 1msec. It shall have the capability of time stamping events.
- m) The RTU clock is normally synchronized by the master station using a standardized protocol every 5 minutes. In the advent that this does not occur the RTU clock shall drift no more than 1 millisecond in 24 hours.
- n) Within the RTU events shall be reported to an accuracy of +/-1msec.
- o) The RTU clock shall be capable of linking to an external high accuracy real time clock if required.
- p) The RTU shall be equipped with a “control/isolate” switch which shall inhibit all control outputs from being executed. The status of this switch shall be monitored by the RTU.
- q) The RTU shall be capable of programming in a high-level language to implement local control and logic routines. It shall also be capable of being programmed using at least two IEC-1131-3 programming languages, i.e.:
 - Ladder diagram (LD), graphical
 - Function block diagram (FBD), graphical
 - Structured text (ST), textual
 - Instruction list (IL), textual
 - Sequential function chart (SFC)

2.5.11 RTU Communication ports:

- a) The RTU shall be equipped and configured to communicate using industrial TCP/IP to the master stations.

- b) The SCADA master station interfaces with the RTUs shall utilize PRASA Rail's MPLS-TP Network communications System. Each RTU shall have Permanent Virtual Circuits (PVC) for communications with Master Station.
- c) Isolation of all communications circuits shall conform to IEC or equivalent Railway Standard for 3kV Traction Substations.
- d) Galvanic isolation shall be provided for any port that is not based on a fibre interface. This is not required for the diagnostic port.

2.5.12 RTU Input & Output structure:

- a) The RTU I/O quantities shall be developed in accordance with requirements based on the substation Equipment Design shown elsewhere in the RFP.
- b) Each RTU interfaces both directly and indirectly with substation Electrical Equipment and protection Systems within the traction Supply power distribution Networks.
- c) The direct interface is via wiring directly from digital and analogue sensors located within the substation Equipment to the RTU, and from relay outputs within the RTU to Equipment panels in the substation. This wiring is routed via the wiring rack.
- d) The indirect interface shall be achieved via a local described TCP/IP communication Network between the RTU and the IEDs in the substation.
- e) Field cable terminations shall define the point of separation between the Electrical SCADA RTU and the substation Electrical System.

2.5.13 Digital inputs:

- a) Digital inputs shall comprise both active & passive types. Where passive inputs are nominated the power shall originate at the input module. Active inputs shall be powered from external Equipment. Both the active and passive inputs shall normally have identical voltage ratings and types which shall be the substation battery Supply voltage.
- b) Digital input signals shall be galvanic isolated preferably using an opto-couplers to the field devices.
- c) Each input shall be provided with individual 'anti-bounce' signal conditioning and noise filtering such that a value can be varied to adjust the sensitivity of the input from 0-30ms.
- d) Each input shall be able to detect a minimum transitional change from High-to-Low or Low-to-High in 4milliseconds. The threshold voltage shall be set such that an input shall not change from Low to High unless the input voltage is at least 35% of the nominal battery voltage and it shall not change from High to Low unless the input voltage is less than 65% of the nominal battery voltage.

- e) Each group of inputs shall be protected by fast acting fuses (or equivalent). Fuse monitoring in groups shall be provided to detect whether fuses have failed and alert the master station operator of this occurrence.
- f) For locations where there are two battery Systems digital inputs shall be clearly labelled to identify which battery System is used. There shall also be separation of inputs from the two battery Systems. The inputs shall be separated by being on different card racks and wiring terminal strips which shall be labelled for identification.

2.5.14 Digital outputs:

- a) Digital outputs shall comprise voltage free contacts rated for switching. Relays shall conform to IEC 60255-3 or equivalent.
- b) Loads shall be typically 110V DC 2 Amp inductive.
- c) Appropriate relays shall be selected for the specific types of load. The minimum contact wetting current shall be specified for the relays selected.
- d) Digital output signals shall have galvanic isolation with opto-couplers.
- e) The preference is to use voltage free contacts for the digital outputs.

2.5.15 Analogue inputs:

- a) Analogue input signals shall have a galvanic isolation with opto-couplers.
- b) Analogue inputs shall be bipolar but normally configured to accept 0-20mA DC or $\pm 20\text{mA}$ DC or $\pm 10\text{mA}$ DC or $\pm 2\text{V}$ DC using full resolution. Eleven (11) bit plus sign resolution shall be provided as a minimum for analogue-to-digital conversion range.
- c) Each input shall be provided with individual Software filtering.
- d) The resistors used to convert the current loop to a voltage shall be precision resistors. The overall minimum accuracy of analogue measurement shall be 0.25% over the full scale and full temperature range. This includes resistors, ADC and Software accuracy.

2.5.16 RTU wiring enclosure racks:

- a) Each RTU shall be supplied fully assembled together with all ancillary Equipment including wiring terminals, mounting rails, wiring ducts and wiring to form a complete System subject only to connection of substation Equipment to field terminals.
- b) Ancillary Equipment to be supplied with the RTU includes the following:
 - X 48v power supplies (110V DC to 48V DC converters,). These are used to power auxiliary communications Equipment and input/output circuits
 - Rack switch/lighting and a 240V AC power point. Note that this circuit wiring shall be done in consultation with substation personnel. The power point shall be mounted near the bottom of the RTU rack

- c) The RTU wiring rack shall incorporate cable-wiring terminals for all incoming field cables.
- d) Terminals shall normally be rail mounted vertically.
- e) Terminals shall be provided for each core of all field cables.
- f) Adequate means of support for field cables shall be provided.
- g) Normal field cable access shall be bottom entry into the wiring rack.
- h) Provision shall be made for both top and bottom entry for field cables if specified by PRASA Rail.
- i) Space shall be allocated between sections of terminals allocated to different cables to provide adequate spacing for labelling.
- j) A minimum label width of 9 mm shall be provided.
- k) Cable assembly shall be provided between each RTU I/O module in the RTU rack and the terminals in the RTU wiring rack.
- l) A space of at least 50mm shall be provided between the cable ducts or cable ladder and the terminals (note that 140mm between the two sets of cable ducts including the terminal have been found to be adequate. This shall be provided to ensure the cores can be manipulated and that adequate space for ferrules is provided.
- m) Where ducting is provided for locating cables the duct size shall be large enough to hold all the cables permitting the duct lid to be fitted when cables are installed.
- n) The Design of the wiring rack layout shall be to PRASA Rail's approval.

2.5.17 RTU Rack Construction:

- a) Racks shall be wall or floor mounting type depending on available space and of the rack manufacturer's standard Design and Construction to IP42.
- b) 1.6mm sheet steel powder coated – storm grey N42 textured powder coat outside, white N14 smooth powder coat inside.
- c) Cable entry normally bottom only but top entry may be specified by PRASA Rail at time of order. Non-ferrous gland plates are required for cable entry.
- d) Swing frame sections may be supplied with PRASA Rail approval to permit easier access to all Equipment in certain configurations.
- e) Door hinges that permit the door to be lifted off.
- f) Full length pad-lockable doors at front and rear.
- g) Door and gland plates shall be fitted with gaskets to provide a dust proof environment to IP51 and shall be suitably earthed with earth straps using 10mm² flexible earth cables.

- h) Main earth stud to be suitable for 70mm² cables.
- i) The RTU power Supply wiring shall be 2.5mm².
- j) Cables between RTU and wiring rack shall be run in 100mm duct via rack tops. In cases where top entry is required ducting should be located at the bottom to give clear ingress to field cables.

2.5.18 RTU Rack assembly:

- a) Wiring terminal strips shall be supplied for all power and signal connections to the RTU hardware.
- b) Wiring terminals shall be supplied for cabling from the field and from the RTU.
- c) Incoming Supply terminals and DC power terminals shall be fitted with the appropriate fuse.
- d) Labels shall be placed to describe each cable from the field and from the RTU.
- e) Suitable labels shall be used to clearly indicate columns of terminals, and other items, e.g. types of inputs, such as “analogue inputs.”
- f) In addition, all major items of Equipment shall be labelled with white-black-white ‘Traffolyte’ type labels suitably engraved with lettering height greater than 5mm.
- g) End Clamps at least at the end of each rail to ensure terminals are locked into place.
- h) Mounting rails shall be sized to provide a minimum of 30% Spare space for future expansion.
- i) Ducting shall be used for wiring/cable containment.
- j) Indication wiring within the RTU and wiring racks shall be multi-stranded 0.75mm²
- k) Control wiring shall be multi-stranded 2.5mm².
- l) Power distribution wiring shall be multi-stranded 2.5mm².
- m) Crimp type boot lace ferrules shall be used on all wiring.
- n) Wiring shall be labelled at each end using sleeve type markers.
- o) The rack shall be earthed with at least 2.5mm² cables.
- p) Wiring used for cross wiring shall be white.
- q) Wiring for 240V AC shall be red/black, 110V DC red/black, 48V DC orange/blue, 24V DC black/white.

2.6 Telephone System for Operational applications

- 2.6.1 This specification is to define the overall functional requirements for the Supply of an automatic telephone System based on the use of voice over IP technologies (VoIP).

- 2.6.2 The function of the telephone System is to allow seamless communications between the train operations management centre personnel, train controllers, train drivers and infrastructure Maintenance personnel.
- 2.6.3 The System shall provide a highly reliable and high availability telephone communications to enable Maintenance quick recovery response to service interruptions that may arise in Signalling operating environments.
- 2.6.4 Telephone System functional requirements:
- a) The System shall be simple in operation to allow use of telephones by untrained Maintenance staff, protection services staff and anyone from the trains operating services that may be required to make Maintenance related call.
 - b) The System shall include remote monitoring and supervision arrangements Designed for ease of Maintenance and to minimise the requirement for Maintenance personnel to do physical checks.
 - c) The System shall be integrally comprised of the following basic elements:
 - Telephones
 - signage
 - Cabling and termination frames
 - PABXs
 - Telephone Testing mechanism
 - d) The phones shall be installed in all:
 - CTCC workstations
 - Every Signalling Equipment Room
 - Every traction substation Equipment Room
 - All GSM-R sites
 - Station platforms for train driver-train controller communications as an alternative to train radios
 - e) The GSM-R Dispatchers that have already been procured shall be used for Train Controller telephones services by being integrated to the PABX System with solution to provide identification of connected parties and one key operation to access other parties cooperating in the System.
 - f) The GSM-R Dispatchers that have already been procured shall be integrated to the existing TFR (Transnet Freight Rail) radio System for seamless communications with any TFR trains.
 - g) The telephone System self-Test functionality shall be incorporated to ensure the telephone are regularly (at least once a month) tested.

- h) The telephone System shall be interfaced to the PRASA ICT Business telephone Network for communications to PRASA business and external public Network.
- i) The telephone System shall be interfaced to the PRASA GSM-R Dispatcher server for communications to TCO Dispatcher external calls to PRASA Business telephone public Network and public Network.
- j) The TCO Dispatcher shall be configured to allow calling of each telephone or by group call to all telephones within operating environments.

2.6.5 Telephone System cabling:

- a) All telephones cabling in the Equipment Rooms and station platforms shall be fire safe cable specifically Designed to address issues of fire management and safety and include properties of low smoke generation, flame retardant, not support combustion, not contain jelly, not contain halogen or other Materials that would produce poisonous or corrosive gas in a fire.
- b) Fire rated cables shall be fire safe and be rated at two hours minimum.
- c) PABX cabling includes all cables required for the PABX Installation such as line interface cable, power and earth cable, data cable.
- d) Cabling from the PABX Equipment to PABX termination points shall be fire safe or made fire safe by containment in a fire safe covering, except for the following situations where standard cabling used for the PABX may be used:
 - Where cabling is contained within the same Equipment rack as the PABX
 - Where cabling is contained within a room that is protected by a fire suppression System
- e) The cable joints shall be used in the cabling Systems.
- f) Cable route for the System shall consist of a heavy-duty tray that is constructed of Materials that are fire safe and resistant to corrosion.
- g) A dedicated tray shall be provided for the System with visible labels at approximately 3 m intervals.

2.6.6 PABX System:

- h) PABXs shall be installed in a telecommunications Equipment Room and powered from the room's power Supply, which shall have a minimum nominal battery backup time of twelve hours.
- i) The access to the public Network shall be protected via firewalls.
- j) The supplied PABX shall be IP-based telephone System Designed for maximum System availability by using redundant communication servers.
- k) The proposed IP based telephone System shall be Designed to make use of the optical fibre Ethernet backbone Network installed in accordance with the chapter Optical Fibre Transmission Network of this specification.

- l) The telephone System shall be able to voice record all telephones connected to it.
- m) All voice records shall be available for immediate replay only to authorized service personnel through the telephone System administration rights.
- n) This recorder shall have facilities to record time and date information, which can be used for retrieving specific recorded messages.
- o) The time and date information shall be synchronized using the GPS time reference.
- p) A workstation shall be provided for access and listening of recorded messages using the time and date information generated by the recorder System.
- q) The telephone System shall be supplied with required terminal licensing for 500 subscribers without requiring replacement of any of the major System Components and expandable to 1000 subscribers.
- r) The telephone System shall be equipped with a Unified Messaging Service (UMS) module for managing and storing voice mail messages. The supplied UMS shall be able to store a minimum of 200 messages with a minimum duration of 2 min per message.

2.6.7 Telephone handsets:

- a) The VoIP-telephones within the technical Equipment Rooms shall be industrial type (shock-proofed).
- b) The following service features shall be available in telephone handsets and supported by the telephone System:
 - Group call for up to 40 members
 - Conference call with the ability to add a third party to an existing call
 - Call waiting
 - Return call for missed call(s)
 - Hands-free capability to enables a subscriber during a phone call to speak and listen without the need of having to physically hold the handset.
 - Caller ID display
 - Call Memory to select any of the last 12 dialled numbers from a stored list
 - Caller switching allows the user during a phone call to switch between two different call parties
 - Automatic call forwarding to allow the user, e.g. during his absence, to have his received calls automatically forwarded to a programmed telephone number.

- Call pick-up to enable a user to pick up (answer) a call from another extension rather than from the ringing telephone
 - Call drop for disconnecting the last party added to a conference call or disconnecting a two-party call
 - Call barring to restrict special calls
 - Call on hold to allow the user during a phone call to place a call temporarily on hold (without disconnecting it) to answer a received call.
 - Call repeat for last dialled number storage
 - Follow me
 - Programmed calls
 - LCD display showing the telephone extension, day, date, time, dialled numbers, numbers of incoming calls or other messages on an alphanumeric display
 - Authorization
 - Unified Messaging Services
- c) Each IP Phone shall be connected to a modular plug, such as RJ45 which shall support both voice and data communications. As a minimum CAT5 cable System shall be used.

2.7 Global Positioning System (“GPS”) - Time Distribution System

- 2.7.1 The Network Time Protocol (“NTP”) is based on universal time coordinated for time synchronisation across all Systems.
- 2.7.2 The System shall be connected to all Telecommunication sub-Systems for accurate time synchronisation
- 2.7.3 GPS functionality:
- a) The GPS receiver at the CTCC shall receive the time source via a rooftop antenna from the GPS satellites.
 - b) The time data shall be transmitted to the NTP (Network Time Protocol) Server.
 - c) The NTP Server shall be linked to the switch, which is part of the fibre optic Ethernet Backbone Network.
 - d) The time distribution System shall use NTP as a common time source, which shall be distributed System wide.
 - e) The Clock System shall provide synchronised time information for all stations of the project area including the CTCC.
 - f) The synchronized time information shall be provided to the Signalling interlocking System via the transmission Network.
 - g) The Systems shall follow the Master (Server) - Slave Principle.

2.8 Asset Protection

- 2.8.1 The Closed-Circuit Television System (“CCTV”) shall provide real time security and surveillance at the Central Traffic Control (“CTCC”) centre, all Equipment Rooms and controlled level crossings to allow seamless monitoring for operators, as well as recording of the captured images for post-event analysis.
- 2.8.2 The CCTV shall provide high quality video/images with the latest proven Technology incorporated in the Design.
- 2.8.3 The CCTV System shall be highly scalable and reliable providing comprehensive System fault diagnostics and System management functions.
- 2.8.4 The surveillance solution shall be reliable detection of, and intervention in, intrusion into a target area (a ‘secure area’) by person’s intent on theft or causing damage or disruption to the train operations.
- 2.8.5 The solution shall enable Command & Control (C2) Systems with fully integrated C4ISTAR proven security Technology.
- 2.8.6 This specification specifies the user requirements technical specifications for the Design, Installation, configuration, Testing and Commissioning of a CCTV solution covering the following high-risk areas:
- a) CTCC.
 - b) Equipment Rooms.
 - c) Level Crossings.
- 2.8.7 Temper and Vandal Proofing:
- a) The cameras shall be installed in such a way that makes it ‘difficult’ for an intruder to change the field of view, i.e. through installing in a ‘suitable’ location/height, use of ‘appropriate’ physical mounting and using security fixings.
 - b) The cameras shall be located and installed in a manner that reduces the opportunity for animal, bird or insect nesting, accidental damage, vandalism, or use as an aid for climbing, yet facilitates expedient access for routine cleaning, Maintenance, service and repair.
 - c) Cameras housings shall be equipped with tamper detection to detect opening through their usual method of opening.
 - d) Tamper detection shall be incorporated to detect removal of cameras from their mountings and, wherever practicable, orientation adjustment.
 - e) Tamper detection shall be included and should be continuously monitored.

- f) The indication of tamper shall be provided at the location and notified to a responsible monitoring desk reporting changes in the specified field of view and deliberate camera masking.
- g) For any tempered camera there shall be a provision for video substitution to monitor the temper location.
- h) Vulnerable Components such as pluggable connectors, control Equipment and recorders shall be in a secure area with tamper-monitored enclosure(s).
- i) Video loss shall be reported.

2.8.8

Command and Control:

- a) The CTCC shall be equipped with a C4iSTAR Security Command Center
- b) The ISO 11064 standard shall be applied in the implementation of the CCTV control room for human factor Design on ergonomics as indicated in Figure 2.

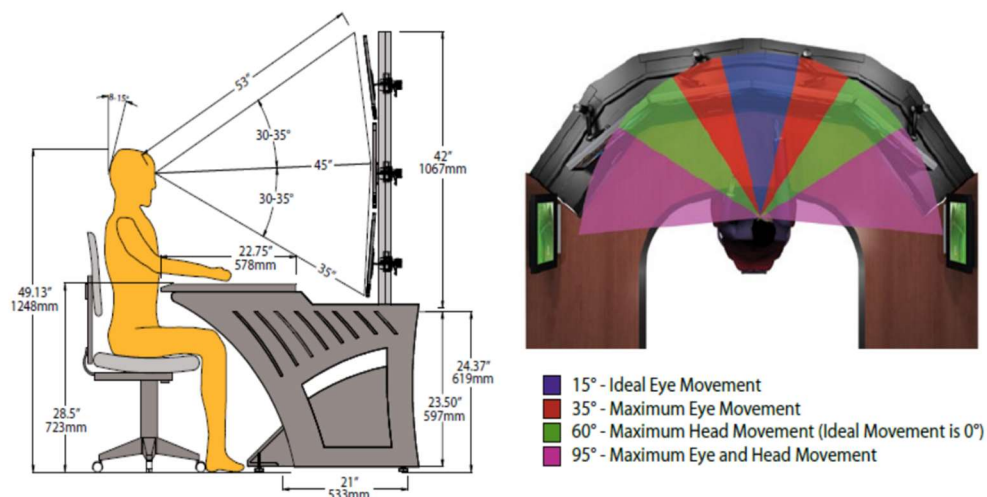


Figure 2: Best viewing angles for an operator

- c) The operator shall be presented with a manageable number of CCTV feeds with 8 cameras views maximum to allow performance of other tasks related to all those camera views, and their anticipated levels of activity.
- d) Camera switching shall be fast and efficient with not more than 0.5 seconds delay between switching from one camera to another.
- e) The Design objective should be to minimise the number of monitors required by implementing control strategies including alarm activation, environmental sensing, intelligent programming and sequencing, and thereby reduce the dependency on the security operators to identify alarm conditions.
- f) The security operator workstation shall be programmed to perform the following functions:
 - Alarm management
 - Manual control of cameras

- Automatic sequencing and control
 - Display of activated cameras
 - Reporting
 - Database management
- g) A Video wall shall be provided based on the monitoring control room space allocations.
- h) The video surveillance:
- Video monitoring shall be developed to sustain the attention of the operator and minimise the risk of the operator missing events that the System has been provided to report
 - “Black screen” policy, whereby an image is displayed only when, for example, unexpected movement or an alarm condition has occurred, minimising operator fatigue and maximising the chance of the desired response shall be applied
 - Continuous monitoring required shall be allocated its own dedicated monitor
 - monitoring screen for tracking live events, allowing separately the other monitor(s) to continue to show their normal scenes shall be implemented based on the surveyed area monitoring requirements
- i) The video Software:
- Video data from fixed and PTZ IP (Internet Protocol) cameras shall be analysed using Software as the video data is streamed into the operator workstation
 - Analytics shall be implemented to perform analysis on video information within selected zones in a more ‘intelligent’ way
 - Analytic shall have the following capabilities:

Object classification	Identify the type of object moving (Person, Animal, Vehicle)
Direction Flow	Identify the direction of a moving object
Loitering	Alert if object stationary beyond a predefined time
Left/Removed object	Alert if an item is left or removed from a predefined area
Face detection	Detect and record faces
People Counting	count people in and out of a defined area
‘Learns’ the normal patterns of human movement in the Designated area of deployment and thereby highlight and log behaviours of individuals who act or move in unusual ways	
Calculate position allowing a target to be tracked over considerable	

distances via multiple cameras relative to a known layout.

When employed with an on, or off, site monitoring service to detect various camera tampering events including video loss

React to the 'signature' of flames/smoke

- j) An alarm signal shall be flagged if an intruder or abnormality is detected.

2.8.9 Camera signage:

- a) Signage alerting customers, employees and any other affected people shall be installed indicating the use and operation of the System in the area consent.
- b) The railway applicable standards for signage shall be used for applicable CCTV signs to be used like Figure 3.





Figure 3: Standard CCTV Signage




2.8.10 Image quality:

- a) The camera shall operate in dark environments by means of starlight Technology to 0.002lux.
- b) The camera shall use a true wide dynamic range (WDR) of 120dB to optimize both the bright and dark areas of a scene at the same time to provide usable video.
- c) The PTZ camera shall have an auto-tracking feature to controls the pan/tilt/zoom functions of the camera to track an object in motion and to keep it in the scene.
- d) The camera shall have an automatic wiper with build-in rain sensor to reduce reliance on manual operation in maintaining unobstructed vision.
- e) The camera shall conform to the ONVIF (Open Network Video Interface Forum) specifications to ensure interoperability between Network video products regardless of manufacturer.
- f) All cameras shall be IP (Internet Protocol) with Power over Ethernet (PoE) at the site of the camera.
- g) IP based cameras with pixel resolution of 3840(H) x 2160(V) (8 Megapixels) shall be used.
- h) High-dynamic-range cameras greater than 95 dB with capability to operate in low-light conditions shall be used.

- i) The camera shall have digital sensors that support flicker reduction while maintaining wide dynamic range.
- j) The signal-to-noise ratio shall be more than 56dB.
- k) The camera shall have a 5.6mm~223mm focal length lens in relation to the size of the image sensor to give the desired fields of view external synchronization.
- l) Table 1 shows various levels of detail that shall be achieved using a single PTZ or single fixed camera of high resolution.

Table 1: Levels of image detail

Purpose	Description (Equivalent pixels/m at target distance)	Relative View (The dashed lines represent the top and bottom of a viewing screen)
Monitor	To enable viewing of the number, direction and speed of movement of people across a wide area, providing their presence is known to the operator.	
Detect	To enable the operator to reliably and easily determine whether any target (e.g. a person or vehicle) is present. 3000m	

Observe	<p>To enable characteristic details of an individual, such as distinctive clothing to be seen, whilst allowing a view of activity surrounding an incident.</p> <p>1500m</p>	
Recognize	<p>To enable the operator to determine with a high degree of certainty whether an individual shown is the same as someone they have seen before.</p> <p>800m</p>	
Identity	<p>To enable identification of an individual beyond reasonable doubt.</p> <p>450m</p>	

Inspect	To enable characteristic details of an individual, such as distinctive clothing to be seen, whilst allowing a view of activity surrounding an incident.	
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- m) All Equipment Rooms' videos and images shall be equipped with fixed cameras with the following capabilities:
- Face identification at 80 Pixels (v)
 - Face recognition at 40 Pixels (v)
 - Human activity observation 200 Pixels (v)
 - Human motion detection 120 Pixels (v)
 - Human operational conditions awareness 48 Pixels (v)

2.8.11 Camera Environment:

- The cameras shall operate in temperatures from -40 °C to +70 °C with 95% humidity.
- The cameras shall be IP67 rated.
- The camera shall allow $\pm 25\%$ input voltage tolerance with 8KV lightning rating to provide effective protection against lightning.

2.8.12 Network Video Recorder (NVR):

- The video retention time shall be more than 31 days as a minimum without compromise on the video quality which must be the same as the live viewed.
- Movement detection feature shall be applied for all the recorded data to optimize the recording capacity.
- Access to the recorders shall be logged on a System management database integrated with administration logging rights and history of activities and events.
- The video signal shall be recorded in uncompressed multimedia files using the H.264 format.
- Playback capability mechanism shall be achievable from any point in time, any camera on the CCTV System seamlessly without having to change access platforms.

- f) Recorded images shall have the time, date and camera location superimposed on the CCTV vision.
- g) A Network Time Protocol (NTP) shall be used for clock synchronisation, PRASA shall indicate if this is available or required to be supplied.
- h) Watermarking on the CCTV vision shall be a feature of the System.
- i) The CCTV Systems shall achieve a frame rates of 25 (fps) or greater, regardless of the number of cameras connected to the System.

2.8.13 Object detection:

- a) Detection shall be implemented as a first means of indication and alert with accurate measurements showing location and supported by CCTV visuals to identify the object for reaction to be implemented.
- b) The security surveillance System shall have the capability to discriminate between the motions of interest and the environment with statistical abnormality detection at minimum distance of 800m for daytime, and 400m night.
- c) Video analytics with motion detection shall be applied and arranged so that an event involving significant movement is brought up on a monitor screen showing a different view, register the change at the image recording device included in the System for the duration of the event and 'bookmarking' the point on the recording at which the event occurred.
- d) Video Analytics System using mass centralised servers shall be used to accommodate existing and new camera Installations.

2.8.14 The Camera Housing and Support:

- a) The camera and communication devices shall be mounted within housings that are rated to IP67 and function satisfactorily in all weather conditions.
- b) The camera System shall be vandal resistance.
- c) The surface coating shall be anti-seawater corrosion.
- d) Material used to cover the lens aperture shall resist scratching or damage by impact to reduce the effects on the quality of the image.

2.8.15 Network Connection:

- a) All switches used for connecting the CCTV cameras shall support PoE functionality.
- b) Wireless radio transmission Network shall be utilized to transport CCTV data to all required Monitoring Centres, the radio shall use the free frequency band.
- c) Where existing transmission Systems are implemented, integration to the System shall be first prioritised with applicable upgrades suitable for required video surveillance capacity.
- d) All the corridor passage cameras shall be connected and transmitted to the Re-Signalling National Control Centres.

- e) A drawing layout on AutoCAD and ArcGIS format shall be Designed and developed aligned with the existing Re-Signalling, GSM-R, and Electrical Fibre Connectivity Layout.
- f) The best practice standard shall be implemented in reducing transmission bandwidth while avoiding slow frame rate causing image flickering.
- g) The supplied Network switches shall be railway standard compliance using MPLS-TP switches for Transmission Backbone, and standard railway approved switches for required IP Layer with no moving objects, respectively.
- h) The applicable railway approved cabling shall be used in relation to Camera / Recorder distance, with consideration for future expansion of about 20% of the complete Design.
- i) The Ethernet transmission System shall be Designed to achieve:
 - An average bit error rate (BER) of not less than $1 \text{ in } 10^9$
 - The effects of EMC/EMI from other connections and sources
 - Full duplex transmission mode with fully redundant standby circuit
 - Minimal Maintenance requirement
 - The line loss between each camera and the multiplexer or recorder that the camera is connected to shall not cause the signal-to-noise ratio to fall below 45dB

3 ENGINEERING

3.1 Design and Build Risk Assessment

- 3.1.1 All Designs shall comply with all relevant Standards, Specifications, Regulations and Procedures as specified throughout the RFP.
- 3.1.2 The Telecommunications System shall comply and be supported predominantly by the following three assessments, which shall be part of the safety case:
- a) System Safety Assessment – SANS 3000-2-5
 - b) Human Factors Integration - SANS 3000-4 Standard
 - c) Security Assessment:
 - IEC/TS 62443 Industrial communication Network – Network and System security
 - ISO/IEC 27000 Information Technology — Security techniques — Information security management Systems
- 3.1.3 The Bidder shall keep these three analyses up to date during the life cycle of the Systems Installation, Commissioning and operations cycles.
- 3.1.4 The Telecommunications System shall have the capability to provide complete security for physical, personnel and cyber threats.
- 3.1.5 A risk-based analysis shall be performed for prevention, detection and response against any vulnerabilities and threats to the Telecommunications System.

3.2 Process Model

- 3.2.1 PRASA Rail Engineering Services has adopted the V-Model Design methodology as a basis for managing System Design process.
- 3.2.2 The Design process with outputs shall be followed in alignment to the V-Model as shown in Figure 3.2.1.
- 3.2.3 The processes on Figure 3.2.2-to-Figure 3.2.6 shall be adopted for execution guideline process to develop required documents in alignment to the V-Model.
- 3.2.4 Site surveys shall be conducted by the Bidder and PRASA for detail Design.
- 3.2.5 During the Design and Installation process, the Bidder shall review and revise the requirements and proposed solution with PRASA to ensure the delivered System achieves its aims and objectives.

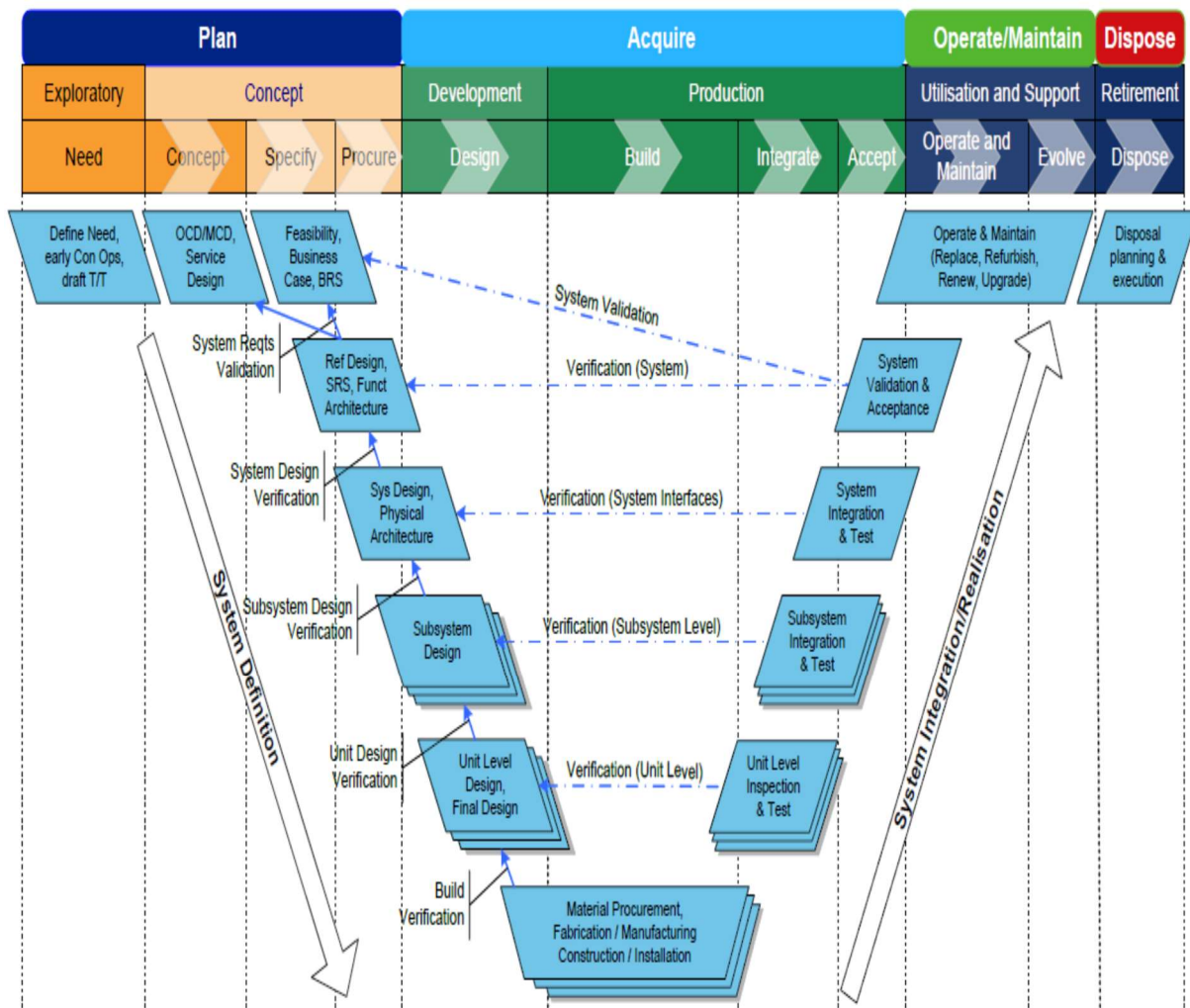


Figure 3.2.1: System Design V-Model

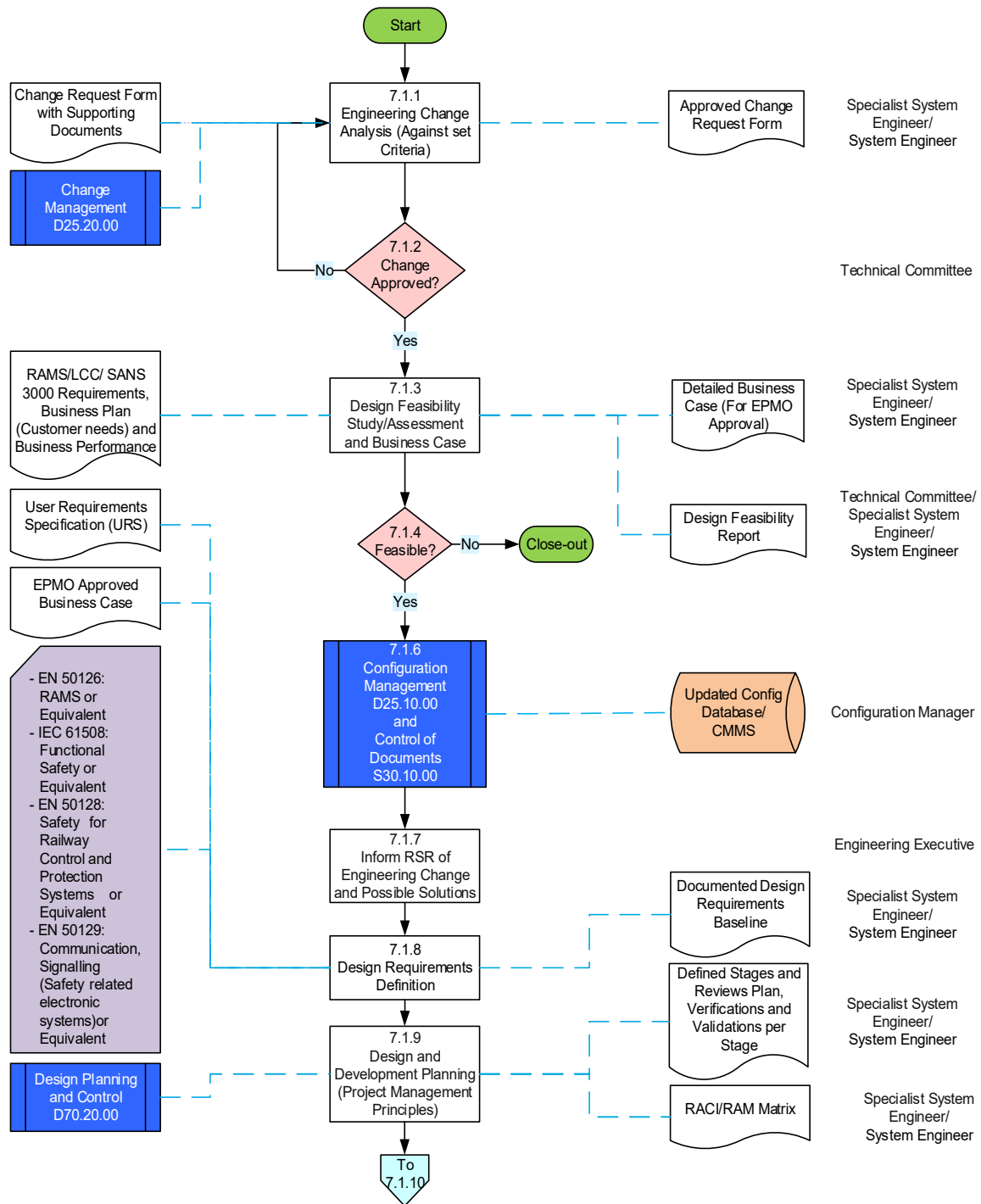


Figure 3.2.2: ENGINEERING_LIB-#134-v1-Design_and_Development_Process.VSD_P1

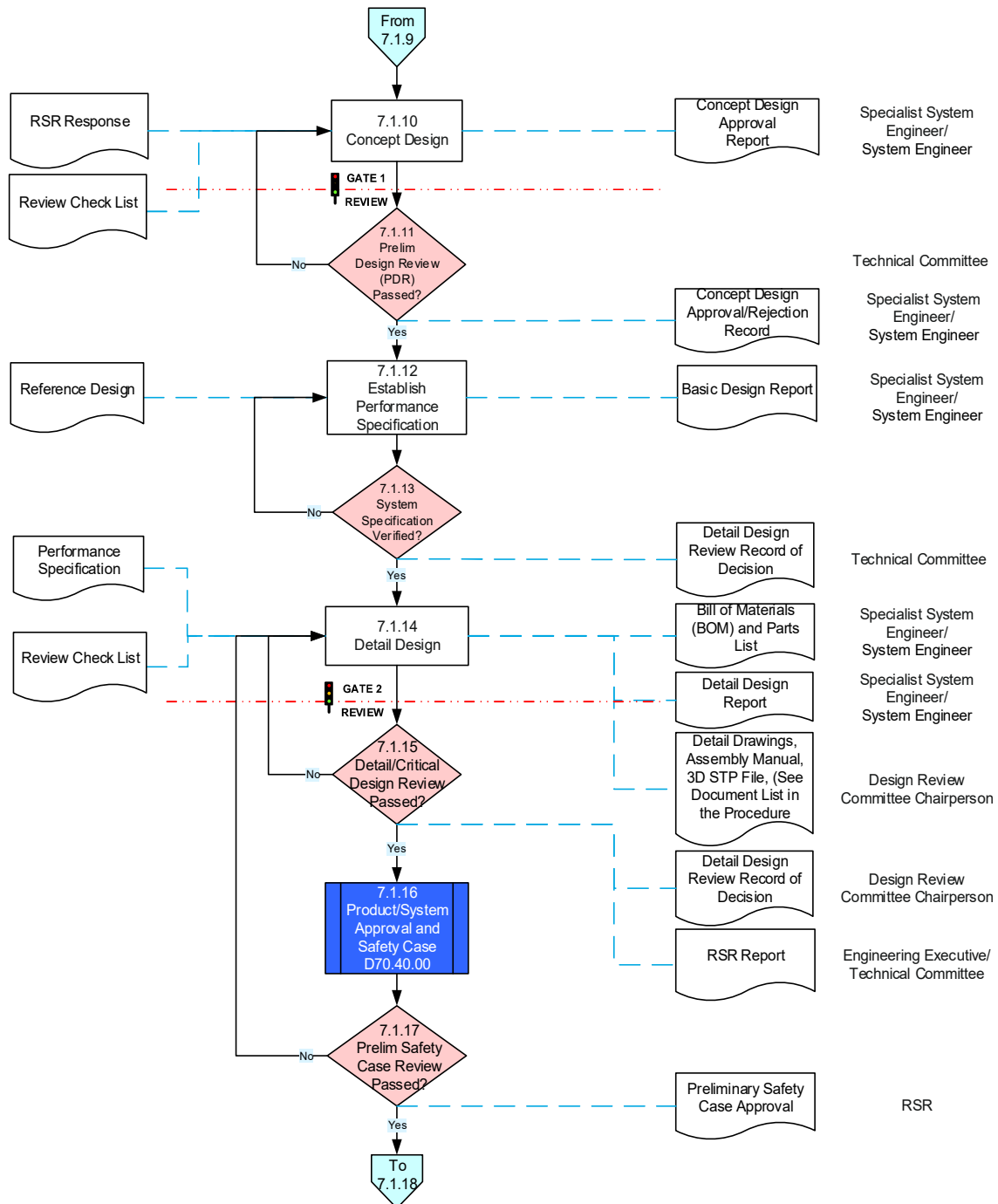


Figure 3.2.3: ENGINEERING_LIB-#134-v1-Design_and_Development_Process.VSD_P2

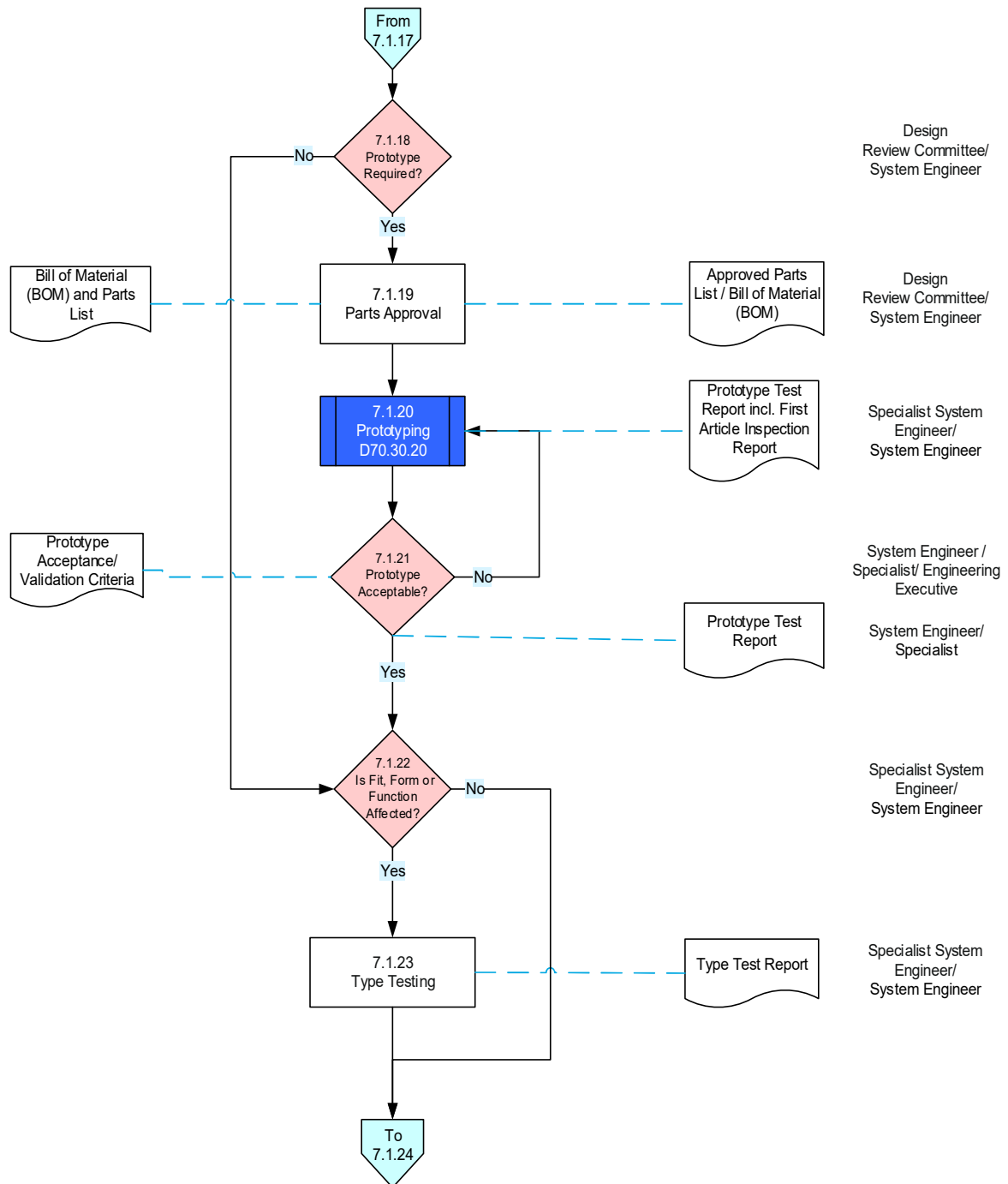


Figure 3.2.4: ENGINEERING_LIB-#134-v1-Design_and_Development_Process.VSD_P3

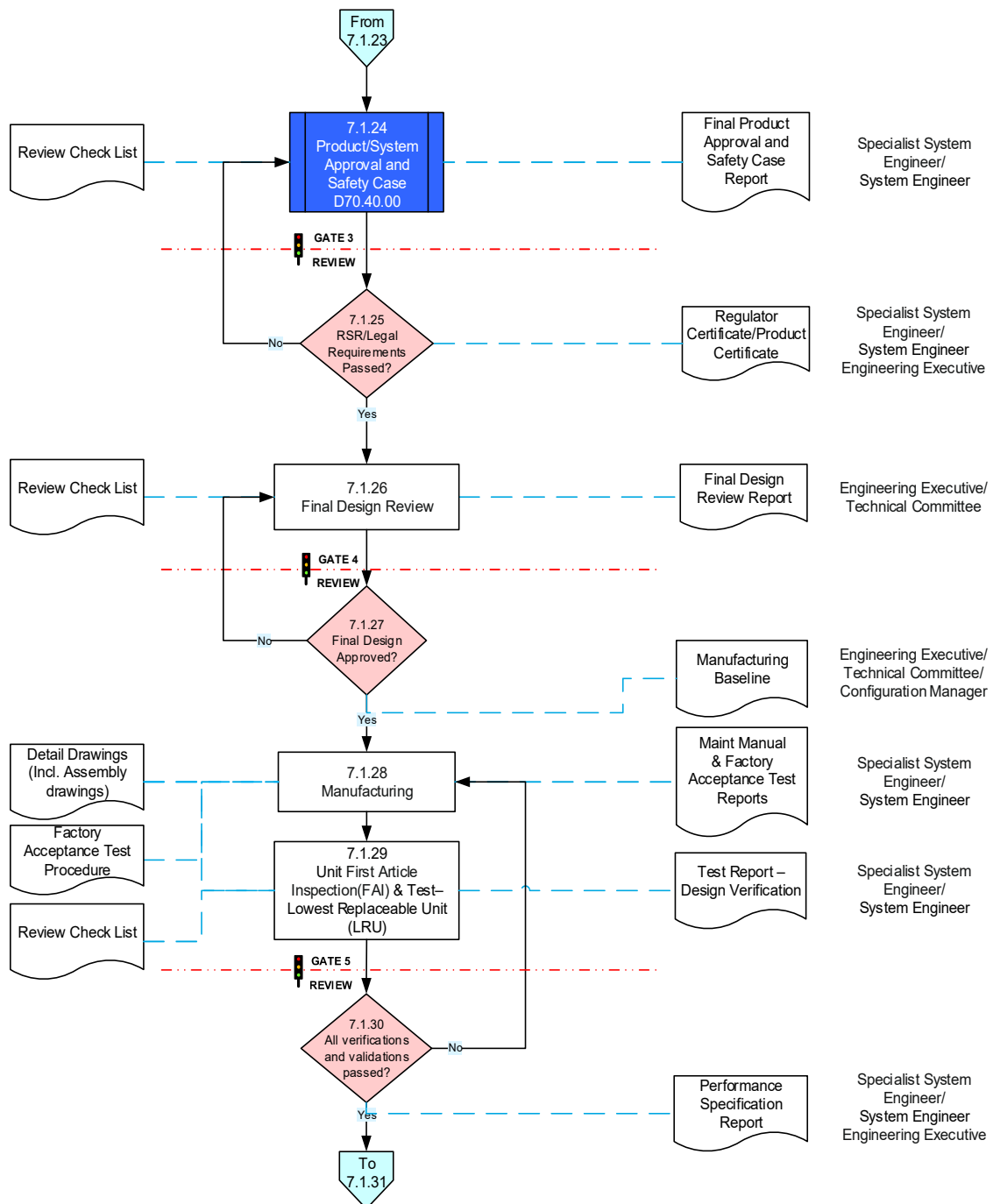


Figure 3.2.5: ENGINEERING_LIB-#134-v1-Design_and_Development_Process.VSD_P4

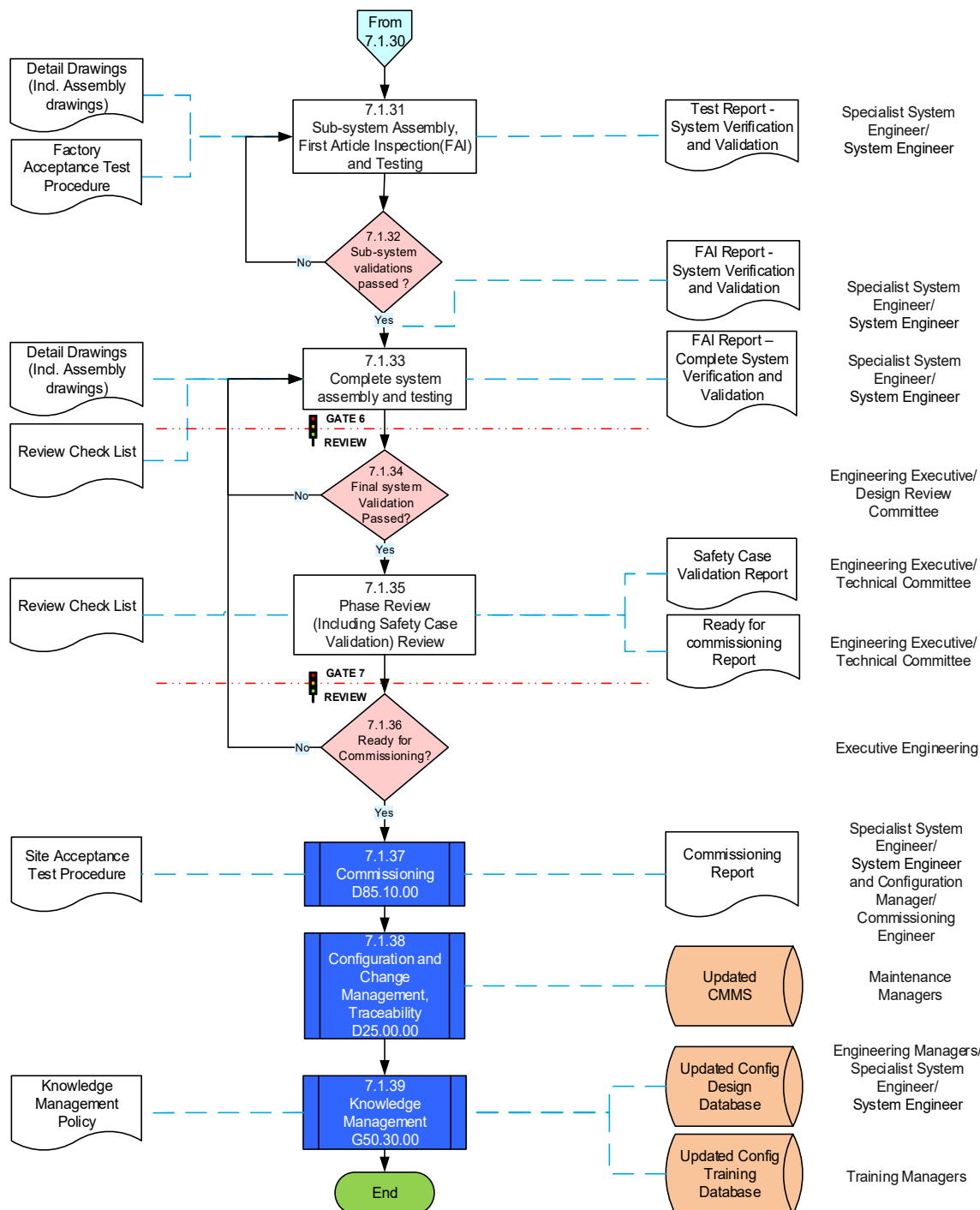


Figure 3.2.6: ENGINEERING_LIB-#134-v1-Design_and_Development_Process.VSD_P5

4 CONSTRUCTION

4.1 General

- 4.1.1 Telecommunication Construction work shall comply with all relevant Standards, Specifications, Regulations and Procedures as specified throughout the RFP.
- 4.1.2 The Bidder shall submit method statements for all Telecommunications Construction work to be performed to PRASA for review and approval before commencement of the work.
- 4.1.3 All Construction work on or near the railway line shall be performed under Occupation-between-trains ("OBT") or Total Occupation conditions.

5 TESTING AND COMMISSIONING

5.1 General

- 5.1.1 All Testing and Commissioning activities to comply with all relevant Standards, Specifications, Regulations and Procedures as specified throughout the RFP.

5.2 Factory Acceptance Testing (“FAT”)

- 5.2.1 Each System shall be fully assembled and configured for factory Testing prior to dispatch.
- 5.2.2 The System shall be supplied defect free.
- 5.2.3 Defects found during site Commissioning and within the warranty period shall result in the part(s) concerned being returned to the Bidder for immediate correction/replacement at the cost of the supplier.
- 5.2.4 All relevant Telecommunications Systems, sub-Systems and Equipment shall undergo and pass FAT before shipping to site.
- 5.2.5 The Bidder shall be responsible for all FAT.
- 5.2.6 All FAT shall be conducted at factory(s) at which the Plant and Materials are manufactured and assembled and by a Telecommunications Engineer or technologist, registered with the Engineering Council of South Africa (“ECSA”) as a professional Engineer or professional technologist and who has undergone training for the specific System, sub-System or Equipment and have experience in FAT.
- 5.2.7 The person(s) responsible for the FAT shall not have been involved in any Design activities relating to the System, sub-System or Equipment to be tested.
- 5.2.8 The Bidder shall submit a FAT Method Statement to PRASA for acceptance before any FAT commence. The Method Statement shall clearly indicate:
- a) All Systems, sub-Systems and Equipment that shall be included in the FAT and which shall be omitted.
 - b) Specification against which the FAT shall be conducted.
 - c) Method of conducting the FAT for each System, sub-System and Equipment.
 - d) Details, including experience reports, of people which shall be conducting the FAT.
- 5.2.9 All FATS shall include but not be limited to:
- e) Point to point wiring check for impedance and continuity.
 - f) Serial numbers of all cards and modules shall be listed in an Excel spreadsheet.
 - g) Confirmation of all modules from the field terminal through to the diagnostic laptop.

- h) Confirmation of control functions from the diagnostic laptop to the field terminals including exercising the dummy circuit breaker and the controls isolate switch.
- i) Confirmation of effective communications between the Systems and other devices using the specified protocols
- j) All powered Tests shall be carried out at the specified power Supply rating of the System

- 5.2.10 The Bidder shall invite PRASA to all FAT taking place at least 40 working days prior to commencing of the FAT. Should PRASA not be able to attend, PRASA shall give the Bidder permission to continue or request the dates for the FAT to be changed. PRASA shall not be held liable for any delays caused by this unavailability.
- 5.2.11 The Bidder shall submit all duly signed FAT Test certificates and associated Test sheet to PRASA for information purposes, prior to Commissioning.
- 5.2.12 Test results for each System showing Tests undertaken, results and any corrective action taken shall be provided in an approved format and shipped with the System.
- 5.2.13 Colour photographs shall be included in the Test results to record the Equipment layout.
- 5.2.14 PRASA accepts no accountability nor liability for any FAT conducted, despite any checks done or inputs given by any of PRASA's agents.

5.3 Site Acceptance Testing (“SAT”)

- 5.3.1 All relevant Telecommunications Systems, sub-Systems and Equipment shall undergo and pass SAT before Commissioning.
- 5.3.2 The Bidder shall be responsible for SAT.
- 5.3.3 The SAT shall be conducted by a Telecommunications Engineer or technologist, registered with the Engineering Council of South Africa (“ECSA”) as a professional Engineer or professional technologist and who has undergone training for the specific System, sub-System or Equipment and have experience in SAT.
- 5.3.4 The person(s) responsible for the SAT shall not have been involved in any Design, FAT or Installation activities relating to the System, sub-System or Equipment to be tested.
- 5.3.5 The Bidder shall submit a SAT Method Statement to PRASA for acceptance before any SAT commence. The Method Statement shall clearly indicate:
- a) All Systems, sub-Systems and Equipment shall be included in the SAT and which shall be omitted.
 - b) Specification against which the SAT shall be conducted.
 - c) Method of conducting the SAT for each System, sub-System and Equipment.
 - d) Details, including experience reports, of people which shall be conducting the SAT.

- 5.3.6 Where practical, all SAT shall be done under OBT conditions, prior to the final Testing and Commissioning Occupation.
- 5.3.7 The Bidder shall invite PRASA to all SAT taking place at least 40 working days prior to commencing of the SAT. Should PRASA not be able to attend, PRASA shall give the Bidder permission to continue or request the dates for the SAT to be changed. PRASA shall not be held liable for any delays caused by this unavailability.
- 5.3.8 The Bidder shall submit all duly signed SAT Test certificates and associated Test sheet to PRASA for information purposes, prior to Commissioning.
- 5.3.9 The PRASA accepts no accountability nor liability for any SAT conducted, despite any checks done or inputs given by any of PRASA's agents.

5.4 Final Testing and Commissioning

- 5.4.1 Final Testing and Commissioning shall be done by a PRASA approved Test and Commissioning Engineer provided by the Bidder.
- 5.4.2 Once the Bidder is convinced the Bidder shall be ready for Final Testing and Commissioning, he shall agree with PRASA on a suitable date for the activity, at least 90 working days prior to proposed date.
- 5.4.3 The Bidder shall submit a comprehensive Final Testing and Commissioning Method Statement to PRASA for approval before any Commissioning commence.
- 5.4.4 The Bidder shall be responsible to provide a complete Testing and Commissioning team as per the Method Statement, as well as all Tools and Equipment required for introducing, Testing and Commissioning of the System.
- 5.4.5 The members of the Bidder's Testing team shall have not been involved in any Design, FAT or SAT activities relating to the System, sub-System or Equipment for which that member is responsible during the final Testing and Commissioning.

6 DECOMMISSIONING, DISMANTLING AND REMOVAL

6.1 General

6.1.1 The Bidder shall, at a minimum, ensure that:

- a) The Decommissioning, dismantling and removal shall comply with all relevant Standards, Specifications, Regulations and Procedures as specified throughout the RFP.
- b) The Bidder shall be responsible for the Decommissioning, dismantling and removal of all old Telecommunications Equipment.
- c) The Bidder shall remove all visible communication cable.
- d) All buried communication cable may be abandoned.
- e) The Bidder shall submit a Method Statement for the Decommissioning, dismantling and removal of all Equipment to the PRASA approval before commencing any work.
- f) The Bidder shall dispose of the Equipment according to the process described throughout the RFP.
- g) The Bidder shall complete the Decommissioning and removal of visible communication cable within 14 calendar days after the Commissioning of any Section.
- h) The Bidder shall complete the Decommissioning, dismantling and removal of outdoor Telecommunication Equipment no later than 30 calendar days after the Commissioning of any Section.
- i) The dismantling and removal of indoor signal Equipment shall not run behind more than one Section after the Signalling work.

7 MAINTENANCE

7.1 Overview

- 7.1.1 The Bidder shall Design the Telecommunication System in such a manner to minimize Maintenance requirements and ensure overall maintainability.
- 7.1.2 The Bidder shall develop Maintenance strategies for all Telecommunication Equipment offered as part of the solution.
- 7.1.3 The System shall be supplied with a minimum number of Ethernet ports that provide a service connection for a laptop PC and a Network connection for management.
- 7.1.4 An Engineering Maintenance Laptop shall be provided with full diagnostics Tools and Software installed with backup packages on a separate USB drive.
- 7.1.5 Test instruments and Centralized Management Tools shall be provided to support Condition Based Maintenance philosophy.
- 7.1.6 The Maintenance Tool shall provide the overall and detailed view of the status of Telecommunications Systems and its sub-Systems to monitor their status in real time and locate and identify issues as quickly and accurately as possible when an incident occurs
- 7.1.7 The mean down time of the Telecommunications System shall not be greater than 40 hours per year on an average.
- 7.1.8 The following parameters shall be set for Telecommunications Systems so that the availability and reliability requirements set can be fulfilled, which shall be supported with evidence-based analysis:
- a) Mean time between Maintenance, both corrective and preventative.
 - b) Mean time to maintain, both corrective and preventative.
- 7.1.9 Telecommunications System shall provide the Maintenance functionalities, including but not limited to the following:
- a) Fault detection facilities.
 - b) Fault isolation facilities.
 - c) Secure remote management.
 - d) Predictive and preventative Maintenance based on the performance history of the assets.
- Required Maintenance personnel to maintain and service all proposed Systems in accordance with this code of practice shall be defined by the Bidder.
- 7.1.10 Preventative Maintenance procedures shall be developed by the Bidder as per the OEM Maintenance requirements.
- 7.1.11 Routine Testing shall be scheduled, and Planning shall be developed by the Bidder to ensure that the Equipment maintained to required System availability of 99.9999 percentile level.

- 7.1.12 The Maintenance procedure shall include repetition of some or all the Commissioning Tests, or a spot check based either on random selection or on some other means of determination.
- 7.1.13 A detailed list of Spares to be held in stock shall be supplied by the Bidder (installer) to cover the period of a 3 years Maintenance cycle based on failure mode analysis.
- 7.1.14 All electronic Telecommunications Systems shall require no routine or planned Maintenance, therefore, no fans or moving parts shall be used in the Systems to avoid any need for Maintenance.
- 7.1.15 The Telecommunication System shall be constructed to resist the entry of dust with a minimum IP code of IP5X.
- 7.1.16 Telecommunication Equipment shall be installed in such a way that a single technician is able to remove and replace for repair purposes, without special Tools and Test Equipment.
- 7.1.17 Restoration of Equipment to full operational use shall be possible within 15 minutes (nominally) of repairs being completed. It shall not be necessary to dismantle (remove multiple pieces of) the Equipment to replace a module.
- 7.1.18 The Spares list shall include the following:
- a) Name and address of the local agent for each item of Equipment.
 - b) list giving the name and address of the manufacturer of each item of Equipment.
 - c) a copy of all Test certificates received with the System.
 - d) a preventative Maintenance programme for all Equipment.
 - e) operating instructions for each item of Equipment.

7.2 First Level Maintenance

- 7.2.1 The Bidder shall perform First Level Maintenance for each Section that has been tested, commissioned and handed over to PRASA from the date of interim hand over to the Completion Date thereafter for 730 calendar days commencing on the Completion Date for the whole of the Works until PRASA issuance of the Performance Certificate thereafter PRASA shall take over Maintenance.
- 7.2.2 First Level Maintenance shall, at a minimum consist of:
- a) A detailed Maintenance and lifecycle financial model.
 - b) Pre-defined preventative Maintenance.
 - c) Pre-defined corrective Maintenance based on visual inspection of faulty Equipment.
 - d) Modular replacement of faulty Equipment, without the need for any Software or hardware configuration.
 - e) Visual condition assessment.

- 7.2.3 It shall be possible to replace faulty Equipment without the need to stop the System or turn the power off.
- 7.2.4 The Bidder shall ensure that the transition of Maintenance responsibilities from the Bidder to PRASA (commencing 90 working days prior to the expiry of the Bidder's total Maintenance period) shall be effortless, that there shall be enough training of PRASA personnel. The Bidder shall further ensure that all documentation, policies, procedures and the like relating to the successful continuation of Maintenance, by PRASA, is transparently and effectively handed over to PRASA.

7.3 Second Level Maintenance

- 7.3.1 The Bidder shall perform Second Level Maintenance for each Section that has been tested, commissioned and handed over to PRASA from the date of interim hand over to the Completion Date thereafter for 730 calendar days commencing on the Completion Date for the whole of the Works until PRASA issuance of the Performance Certificate thereafter PRASA shall take over Maintenance.
- 7.3.2 Second Level Maintenance shall, at a minimum, consist of:
- a) A detailed Maintenance and lifecycle financial model.
 - b) Pre-defined corrective Maintenance based on System diagnostics.
 - c) Equipment replacement, with the need for basic Software or hardware configuration.
 - d) Condition assessment by means of diagnostic Tools and Equipment.
- 7.3.3 The Bidder shall ensure that the transition of Maintenance responsibilities from the Bidder to PRASA (commencing 90 working days prior to the expiry of the Bidder's total Maintenance period) shall be effortless, that there shall be enough training of PRASA personnel. The Bidder shall further ensure that all documentation, policies, procedures and the like relating to the successful continuation of Maintenance, by PRASA, is transparently and effectively handed over to PRASA.

7.4 Third Level Maintenance

- 7.4.1 The Bidder (with assistance from PRASA) and the Original Equipment Manufacturer ("OEM") (under management of the Bidder and for whom the Bidder shall ensure availability and compliance), shall perform Third Level Maintenance for each Section that has been tested, commissioned and handed over to PRASA from the date of interim hand over to the Completion Date thereafter for 730 calendar days commencing on the Completion Date for the whole of the Works until PRASA issuance of the Performance Certificate thereafter PRASA shall take over Maintenance.
- 7.4.2 Third Level Maintenance shall, at a minimum, consist of:
- a) A detailed Maintenance and lifecycle financial model.
 - b) Undefined and irregular corrective Maintenance based on advanced System diagnostics.

- c) Modular replacement, with the need for advanced Software or hardware configuration.
 - d) System configuration changes to accommodate infrastructure upgrades and layout changes.
- 7.4.3 The Bidder shall do local Supplier Development, training and certifying local Suppliers to perform third level Maintenance on the System further ensuring comprehensive inclusion of the OEM throughout the process.
- 7.4.4 The Bidder shall train and develop a minimum of 2 local suppliers further ensuring comprehensive inclusion of the OEM throughout the process.
- 7.4.5 The Bidder (with direct support from the OEM) shall ensure that the transition of Maintenance responsibilities from the Bidder and the OEM to PRASA (commencing 90 working days prior to the expiry of the Bidder's total Maintenance period) shall be effortless, that there shall be enough training of PRASA personnel. The Bidder shall further ensure that all documentation, policies, procedures and the like relating to the successful continuation of Maintenance, by PRASA, is transparently and effectively handed over to PRASA.
- 7.4.6 Training shall require on all supplied System for both Engineering and Maintenance.
- 7.4.7 The training shall cover aspects of the System Design enough for the Engineering and Maintenance to manage the System over its Design life.
- 7.4.8 Operators requirements shall be covered fully in the training process to ensure correct operation of the System, this training shall be provided by the System OEM.
- 7.4.9 Maintenance training contents shall include:
 - a) System operation and data communications
 - b) Diagnostic Tools provided with the System and Test Equipment to fault find
 - c) System Failure modes
 - d) Configuration of the System

7.5 Fourth Level Maintenance

- 7.5.1 The Bidder and the OEM (under management of the Bidder and for whom the Bidder shall ensure availability and compliance), shall perform Fourth Level Maintenance for each Section that has been tested, commissioned and handed over to PRASA from the date of interim hand over to the Completion Date thereafter for 730 calendar days commencing on the Completion Date for the whole of the Works until PRASA issuance of the Performance Certificate thereafter the OEM shall take over Maintenance (under supervision from PRASA).
- 7.5.2 Fourth Level Maintenance shall, at a minimum, consist of:
 - a) System upgrades
 - b) Changes to the System's core Software
 - c) Component level corrective Maintenance

- 7.5.3 The Bidder shall ensure that the OEM contractually commits to having representation, and providing all necessary Maintenance and/or support, in South Africa for a minimum period of at 240 calendar months post the Bidder's Maintenance, Warranty and Defects Liability period.

8 WARRANTIES

8.1 General

- 8.1.1 The Bidder shall, take interim Warranty responsibility and liability for each Section of that has been tested, commissioned and handed over to PRASA from the date of interim hand over to the Completion Date.
- 8.1.2 The Bidder's full Warranty responsibility and liability period shall be 730 calendar days commencing on the Completion Date for the whole of the Works until PRASA issuance of the Performance Certificate.
- a) Warranties shall, for all Telecommunications related Works, at a minimum, be valid and cover:
 - Replacement of all faulty Plant and Materials, Components and labour for all Maintenance Levels described elsewhere in this document
 - Tracking and tracing and correcting of any Software faults
 - b) Failures caused by the environmental and infrastructure conditions as specified throughout the RFP including, but not limited to:
 - Any Plant and Materials or Components damaged due to exposure to extreme direct sunlight and elevated temperatures
 - Any Plant and Materials or Components damaged due to continues exposure to high humidity
 - Any Plant and Materials or Component failure due to corrosion