Gladstone Ports Corporation

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Engineering Site Standard

GPC-ESS-504
Communications Cabling & Topology

Brief description

This Engineering Site Standard outlines the requirements for communications cabling and network topologies at Gladstone Ports Corporation sites.

This standard does not cover specific details regarding wireless communications, radios, encryption or GPS.

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If you require any further information, please contact the Custodian.

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1 Terms and definitions

Terms commonly used in this specification are listed below with their definitions:

“ACMA” means Australian Communications and Media Authority.

“BNC” means a miniature quick connect/disconnect radio frequency connector used for coaxial cable. It is a quarter turn bayonet connection.

“CCTV” means a Closed Circuit Television.

“EMI” means Electromagnetic Interference.

“EMC” means Electromagnetic Compatibility.

“FOBOT” means Fibre Optic Break Out Tray.

“FORA” means Fibre Optic Rotary Accumulator (Slip Rings).

“GPC” means Gladstone Ports Corporation.

“GPS” means Global Positioning System.

“GSM” means Global System for Mobile Communication.

“HMI” means Human Machine Interface.

“HV” means High Voltage.

“I/O” means Input Output.

“ITC” means Inspection and Test Certificate. A QA document that details the specific inspection and test requirements for a piece of equipment or plant, to prove that it operates in accordance with its design specifications.

“ITP” Inspection and Test Plan. The ITP includes drawings plus a complete set of Inspection and Test Certificates (ITC’s).

“IP” means Ingress Protection

“LAN” means Local Area Network. The SCADA and Corporate Ethernet networks are completely independent.

“LC” means Fibre connector (“little connector”) in accordance with IEC 61754-20

“MAC” means Media Access Control address – a unique identifier assigned to a network interface controller.

“MCC” means Motor Control Centre.

“MRP” means Media Redundancy Protocol.

“MTP/MPO” means Multi-Fibre Push-On/Pull-Off Connector in accordance with IEC 61754-7. A high density fibre connector for SM or MM multi-fibre ribbon. An MTP connector mates with and MPO socket.

“OLTS” means Optical Loss Test Set, used to test end-to-end losses in a fibre optic cable using a light source and power meter.

“OM1” means OM1 Grade Multimode fibre (62.5/125m).

“OM4” means OM4 Grade Multimode fibre (50□m).

“OPC” means OLE for Process Control. An application layer of the Ethernet protocol.

“OS1” means OS1 Grade Singlemode fibre.

“OTDR” means Optical Time Domain Reflectometer, used to identify significant fibre optic point losses or return losses.

“PA” means Public Address

“PC” means Personal Computer

“PLC” means Programmable Logic Controller

“POE” means Power Over Ethernet (IEEE 802.3)

- Up to 12.0 watts (350mA) for Type 1 devices
- Up to 25.5 watts (600mA) for Type 2 devices
- Up to 55 watts (600mA per pair) for Type 3 devices
- Up to 100 watts (960mA per pair) for Type 4 devices

“REP” means Resilient Ethernet Protocol

“RFI” means Radio Frequency Interference

“SCADA” means Supervisory Control and Data Acquisition

“SC” means Fibre connector (“square connector”) square push-pull coupling in accordance with IEC 61754-4

“ST” means Fibre connector (“straight tip”) bayonet style in accordance with IEC 61754-2. This is the preferred connector for multimode fibres.

“TCP” means Transmission Control Protocol

“TDR” means Time Domain Reflectometer (Coaxial cable tester). Refer also OTDR for Fibre Optic Cable tester.

“UPS” means Uninterruptible Power Supply

“USB” means Universal Serial Bus

“VLAN” means Virtual Local Area Network (as defined in IEEE 802.1Q)

“VPN” means Virtual Private Network. An application layer of the Ethernet protocol.

“WPA” Wi-Fi Protected Access security protocol for wireless networks (IEEE 802.11i). WPA2 or WPA3 are the preferred wireless encryption methods.

“Campus Backbone” means Links between major substations and/or server rooms

“Building Backbone” means Links between a major substation and a minor substation or transfer house.

“Horizontal Cabling” means structured cabling between communications racks/cabinets and wall points or field cabinets, which termination devices will connect to via patch leads.

“Work Area Cabling” means Patch Leads

“Shall” indicates that a statement is mandatory.

"Should" indicates a recommendation.

"Testing" means quality control means by which the capability of a manufactured item to meet its specified requirements is determined and documented by subjecting the item to a set of operating conditions.

2 Scope

This Standard defines the requirements and guidelines for communications cabling and topology.

3 Installer Requirements

This section describes the minimum requirements that all communications cable installers shall abide by whilst working on GPC control systems cabling.

3.1 ACMA Registration

All nominated communications technician's must hold and present to the GPC Representative prior to commencing work an ACMA Open Cablers Registration and relevant endorsements for all cabling work being undertaken.

3.2 Panduit Certification

All horizontal copper/Cat6A cabling intended for Ethernet use shall be undertaken using equipment and installation services certified under Panduit's Structured Cabling system. All communications technicians installing Cat6A cabling must hold and present to the GPC Representative prior to commencing work their Panduit Certified Installer Certificate and their employing companies Panduit ONE^{SM} Partner certificate confirming their eligibility to participate in the Certification Plus^{SM} System Warranty Program.

The Installer shall register the installation with Panduit for the Panduit Certification Plus^{SM} System Warranty program. The warranty certificate shall be issued to GPC on completion of the Testing and Commissioning process with that documentation.

4 Fibre Optic Cable Installation

4.1 Cable Route

The route as shown on the design drawings approved for construction shall be followed. In cases where a change of route/line is necessary, the installation contractor shall submit its proposals along with any supporting evidence to GPC for review and authority to proceed. Any deviations shall be recorded as work progresses on as-built drawings.

4.2 Fibre Optic Cable Management

Improper handling of fibre optic cables during installation, splicing and setting can affect their long-term transmission characteristics, even without producing any immediately obvious physical damage or transmission loss.

- The installation contractor shall inspect and test all fibre cables on delivery to the jobsite in accordance with this specification, and shall only proceed with installation of the cable when fully satisfied there is no damage/defects to the cable.
- For non-armoured cable, the minimum bend radius shall be no less than 50 times the cable diameter during installation, and no less than 10 times the cable diameter during storage or after installation. For armoured cable, the bend radius is 50 times the cable diameter during installation and the working bend radius can be reduced to 15 times the cable diameter. In no case shall the bend radii be less than that recommended by the cable manufacturer for installation or storage.
- During installation, if it becomes necessary to pull off cable for a mid-span installation, a figure eight configuration shall be used. The figure eight shall measure a minimum of 3 meters, with each loop 1.5 meters in diameter. Fibre optic cable shall not be coiled in a continuous direction except for lengths of 30 meters or less. To prevent cable damage the figure eight shall be protected by barricade.
- Under no circumstances shall the fibre cable be dragged along the ground.
- Unterminated cable ends shall be capped at all times using a heat shrink seal or equivalent to prevent damage to the cable cores, or dust/moisture ingress.
- Cable shall be protected from pedestrian and vehicle traffic.
- Use a cable pulling grip, especially if fibres are pre-terminated. The load must be applied to the strength-bearing members of the cable, unless the cable is tight-buffered or steel wire armoured.
- Pulling tension shall in no case exceed 2700N, and shall not exceed the cable manufacturers recommendation. The installation contractor shall submit to GPC for review calculations and supporting information demonstrating that maximum pulling tension will not be exceeded during the installation process. Cable pulled using a winch shall have a recording dynamometer with an automatic cut-off, or a pulling grip with a breakaway mechanism.
- Inspect the cable run to ensure there are no sharp edges or bends.
- Use a swivel when pulling to make sure twists in the pull rope are not translated to the fibre-optic cable.
- After pulling, cut off approximately 3m of cable from the pulling end to remove any portion of the cable that may have been stretched or damaged during installation.
- At all splice locations, 10 meters of slack cable shall be coiled from each cable end for splicing, testing and future maintenance. On completion of the splice, the maintenance cable loop shall be carefully placed, set, and fixed securely in accordance with this specification.

4.3 Fibre Optic Cable Terminations

Optical Fibre terminations shall be completed by fusion splicing pigtail assemblies of ST connectors. Termination via mechanical splices and/or puck and polish connectors is not acceptable. Fusion splice equipment shall be calibrated, recently serviced, and suited to the operation.

The fusion-splicing machine shall be capable of splicing loose tube and tight buffered cable. The fusion splicing machine shall have built in features including data storage memory with download facility to a computer, automatic arc test adjustment, fully automatic core alignment with illuminated V grooves for easy fibre loading, fully automatic splicing with splice loss estimation, and LCD display for clear fibre image monitoring of the fusion splice process.

- All optical fibres shall be terminated into a FOBOT in a straight through manner. Cable cross-overs shall be done by the end device patch leads.

- The splicing shall be performed in a clean wind-free environment to avoid dust or other particles that may cause substandard results during the fusion process.
- The fibre tubes shall be cleaned thoroughly, using a solvent recommended by the manufacturer.
- All fibre cores shall be terminated, unless specifically instructed by the GPC supervisor.
- The strength member shall be securely fixed to the strength member clamp. Any excessive length shall be cut to avoid fibre damage.
- Any metallic members of the cables shall be appropriately bonded and earthed.
- Fibre strands shall be organized so that the first twelve strands are placed at the bottom of the closure (the first tray). These shall be progressively followed by the remaining strands, in groups of 12 or 24, with last group being placed on the last tray, keeping in mind fibre and buffer tube segregation requirements.
- After splicing and inspection are complete, the fibre shall be tested for attenuation loss at the splice point. Testing shall be carried out in accordance with this specification. Average two way splice loss of typically 0.03 dB or less is acceptable. Splices that do not meet the required loss figure shall be respliced a total of three more times. If a satisfactory result cannot be achieved after re-splicing and careful checking of the splicing machine, the installation contractor shall inform GPC who may consider accepting the splice, provided that the loss is not excessive, in terms of the overall optical loss budget.
- After the splice has been completed, a splice protection sleeve must be installed, covering a minimum of 15 mm on each side of the stripped coating. The fibre shall then be coiled, labelled and arranged on the tray in accordance with the manufacturer's recommendations.

4.3.1 Fibre Optic Enclosures

Protective enclosures shall be firmly supported to avoid damage by vibration, cable creep, or other mechanical stresses. Fibre enclosures have two broad categories: hermetic (sealed) and free-breathing. Hermetic cases prevent entry of moisture and air but lack ventilation so become hot if exposed to sunlight or other sources of heat. Free-breathing enclosures allow ventilation but can also admit moisture, insects and airborne contaminants. Selection of the correct housing depends on the cable and connector type, the location, and environmental factors. Careful assembly is required to ensure good protection against the elements, which could include physical shock and vibration, water spray, water immersion and dust.

4.3.2 Labelling

All communications cabling is to be labelled as per GPC-ESS-204 “Electrical Drafting, Drawing and Naming Requirements”.

4.3.3 Strain Relief

Cables shall be protected using metallic cable tray or conduit. Cable installed on vertical runs shall be strapped at intervals of 1 meter, ensuring cable is not damaged by over tightening of the straps. Strain relief may also require loops to be installed for vertical runs at a minimum of 10m intervals.

4.3.4 Fibre Core & Tube Colour Coding

Fibres and fibre tubes shall be colour coded blue.

4.3.5 Fibre Patch Cable Colour Code

The following table lists the fibre optic patch lead sheath colours. Sheath colours vary depending on the system the system the fibre is being used for.

Main Function	Sheath Colour
Camera Systems	Green
Fire Systems	Red
Multimode fibre (General)	Orange
Singlemode fibre (General)	Yellow
Site Water/Dust Suppression	Aqua
Wi-Fi Backbone	Purple

4.3.6 Fibre Optic Slip Rings

To interface communication network infrastructure to moving machines at GPC (Ship Loaders and Trippers), fibre optic and copper slip rings are used. The fibre optic rotary units transmit optical signals either through an infinite turn prism based rotary joint, or a limited turn cable based rotary accumulator. The Fibre Optic Rotary Accumulators (FORA) are typically 18-core units (12 x 62.5/125um + 6 x 9/125um), with ST connectors into the non-rotating termination box.

The manufacturer's installation details must be followed at all times during installation and testing. Prior to performing maintenance on the reeler, ensure that the machine long travel and reeler motor are isolated by an authorised person. Ensure the cable is routed and fixed such that it cannot interfere with the rotating parts of the FORA mechanism. The FORA mechanism is maintenance-free, but should be inspected and tested using an OTDR at least every 2 years. The total signal loss shall be less than 3dB including connectors.

5 Fibre Optic Cable Testing and Inspection

5.1 Performance Testing

AS/NZS 3080 and IEC 14763-3 shall be the guiding influence for all fibre optic testing.

Performance of optical fibre connectors are quantified by *Insertion Loss* and *Return Loss*, as defined in IEC 61753-1. The standard includes five grades for insertion loss 'A' (best) to 'D' (worst), and 'M' for multimode. Return loss is graded as '1' (best) to '5' (worst). Test results shall aim for low insertion loss and high return loss (low amounts of reflection at the interface). A power meter and light source or an optical loss test set (OLTS) shall be used to test end-to-end loss, and an optical time-domain reflectometer (OTDR) shall be used to identify significant point losses or return losses.

Typical multimode graded-index fibres have 3 dB/km of attenuation loss (50% loss per km) at a wavelength of 850 nm, and 1 dB/km at 1300 nm. Singlemode 9/125 loses 0.4 dB/km at 1310 nm and 0.25 dB/km at 1550 nm. Each connection adds about 0.6 dB of average loss, and each joint (splice) adds about 0.1 dB. The requirement for insertion loss shall be lower than the specified values in Tables 3 and 4 of AS/NZS:14763.3.

5.2 Manufacturer's Test Results

The installation contractor shall submit to GPC the cable manufacturer's factory test results for all fibre optic cables. The factory drum test results shall demonstrate that the fibre cable meets all manufacturer's (and industry standard) minimum performance criteria.

5.3 Pre-Install Test Results

The installation contractor shall test all fibre optic cabling upon arrival at the jobsite, prior to installation. This testing shall consist of:

- 850nm and 1300nm wavelengths for multimode fibre (MM)
- 1310nm and 1550nm wavelengths for single mode fibre (SM)
- Test 100% of fibres (MM and SM) for attenuation and anomalies in accordance with IEC-60793-1-40, Method C.
- The data shall be recorded electronically, and submitted to GPC for review. If required, a licenced copy of the necessary software shall be supplied to view the results.

5.4 Post-Install Testing

Testing shall not be undertaken until all permanent labelling for cables to be tested has been completed.

The installation contractor shall perform post-installation bi-directional testing of all fibres at:

- 850nm and 1300nm wavelengths for multimode fibre (MM)
- 1310nm and 1550nm wavelengths for single mode fibre (SM)
- Test 100% of fibres (MM and SM) for:
  a) Length and anomalies in accordance with IEC-60793-1-22, Method B.
  b) Optical attenuation and polarity in accordance with:
     - IEC-61280-4-1, Method 2 for MM fibre
     - IEC-61280-4-2, Method 1a for SM fibre
- The data shall be recorded electronically, and submitted to GPC for review. If required, a licenced copy of the necessary software shall be supplied to view the results.

5.5 Testing Procedures

All test equipment shall be calibrated and suitable for the application. The calibration information shall be recorded at the time of each test and included in the Inspection and Test Plan (ITP). OTDR test results for each cable (or cable segment) shall be collated into a single inspection and test certificate (ITC). Multiple cables shall not be grouped together within the same document.

Attenuation test results for each cable (or cable segment) achieved through the use of an optical loss test set (OLTS) shall be entered into an electronic spreadsheet presenting, and capable of automatically calculating, an acceptance/rejection determination based upon the following displayed minimum criteria:

- Optical power reference value
- Cable end-to-end attenuation value
- Cable optical length
- Cable attenuation coefficient
- Quantity of splices
- Quantity of mated connector pairs
- Repair margin
- Operating margin

The spreadsheet shall be submitted with the OTDR test results, with the optical length values based on the OTDR-calculated optical length.

The ITC for each cable shall include as a minimum the following details for each channel:

- Cable Number and/or Office Identification Number
- Test Equipment, Test Configuration and Test Equipment calibration date.
- Wire Map Testing
- Continuity Testing and Polarity testing.
- Cable Length
- Cabling performance parameters as specified in the latest revision of AS/NZS 3080 including addendums.
- Power Loss Budget
- Separate splice insertion loss test results for all field splices.
- Frequency Response/OTDR graphs when possible.
- Test Outcome
- Date and Time of testing
- Name and Signature of testing technician.

All acceptance and test reports shall be submitted to the GPC representative in electronic format. Native files must be submitted. Scanned PDF's from printed pages are not acceptable.

5.6 Panduit Test Procedures

Testing procedure for all Panduit equipment shall as a minimum follow Panduit's recommended procedures to satisfy certification for the Panduit Certification Plus warranty. Panduit's applicable testing procedures are listed below:

- Panduit testing procedure PN445 for testing of multimode and singlemode fibre optic cable systems.
- Panduit testing procedure PN523 for the testing of TX6 copper cable systems.

6 Copper Network Cable Installation

6.1 Cable Management

- For copper communications cables, the minimum bend radius shall be no less than 10 times the cable diameter during installation and no less than 4 times the cable diameter during storage or after installation. In no case shall the bend radii be less than recommended by the cable manufacturer for installation or storage.
- The installation contractor shall ensure that pulling tension applied to each cable does not exceed 110N. In no case shall the pull force be greater than recommended by the cable manufacturer.
- All horizontal cabling shall use Category 6/Class A, Advanced MaTriX 4-pair copper cable, with min 23 AWG copper conductors, twisted in pairs and separated by a cross divider.
- The length of an individual cable run of horizontal cabling shall not exceed 90 metres. Cable performance over 100 metres will exceed the requirements of ANSI/TIA-568 Category 6A and ISO 11801 Class E standards for supporting 1GBASE-T transmission over twisted-pair cabling systems.
- Splicing is not authorized for any copper network cabling.
- Installations will be kept a minimum of 150mm away from light fixtures or other known sources of electromagnetic interference.
- Conduit fill capacities prescribed in ANSI/EIA/TIA-569 shall be observed.

6.1.1 Horizontal Cable Management

- The horizontal cable manager shall be accessible from the front of the cabinet for consumption purposes, and from the side or rear for troubleshooting & maintenance purposes, and shall consist of a 1-piece moulded plastic construction.
- The horizontal cable manager shall include appropriate provisions for bend-radius control, and include a hinged cover that allows access to the cable pathway without having to completely remove the cover from the manager.
- Horizontal cable managers will not exceed more than 2RU in height.
- Velcro ties should be used in the securing or bundling of cabling against physical structure. The use of nylon/zip ties is not permitted.
- Horizontal Cable Slack / Service Loops shall be provided at each end of a structured cable. Excepting situations where physical room constraints exist, 3m of cable slack shall be maintained in all cables, with the slack stored in “a figure 8” service loop. At the wall-point end, slack of no less than 1m shall be retained.
- Cable Jacket removal shall not exceed 25mm.
- The use of duplexing adapters (splitters) is not permitted.

6.2 Termination

6.2.1 UTP Terminations

- All UTP terminations will be contained in designated patch panels housed inside telecommunications enclosures for troubleshooting and maintenance purposes.
- When cross-over connections are required (ie. Tx/Rx or RTS/CTS) for certain applications, they shall be provided external to the cabling system.
- Cat6 UTP Terminations:
  a) Termination jacks shall meet the ANSI/TIA-568 Category 6A Standard.
  b) The termination shall be accomplished through the use of a forward motion termination cap. The termination shall not employ the use of a punch-down tool.
  c) The termination will employ strain-relief against the cable jacket, and be undertaken using the T568A wiring scheme.

6.2.2 Coaxial Cable Terminations

- BNC connectors are the preferred connection method for coaxial cables associated with radio frequency signals, and control networks such as ControlNet. Be aware that a 75 ohm end-of-line resistor may be required for ControlNet segments to prevent signal reflection at the end of the cable.

6.3 Copper Network Cable Testing

6.3.1 Twisted Pairs (CAT-6)

Copper network cables (CAT-6) shall be tested to AS/NZS:61935.1.

In accordance with AS/NZS 3080 and IEC 61935-1, the Installation Contractor shall use a Level III cable tester for Category 6 cable tests. All cable tests shall be submitted electronically on individual ITC’s, including a download copy from the cable tester if available.

6.3.2 Coaxial Cable Test

The installation contractor shall conduct a pre-installation test of coaxial cable using a Time Domain Reflectometer (TDR), for:

- Impedance
- Return Loss
- DC Loop Resistance
- Length

Test results shall meet or exceed the cable manufacturer's published specifications. Factory pre-fabricated coaxial cables such as ControlNet do not require additional testing unless damaged or aged.

6.3.3 Universal Serial Bus (USB)

USB cables are used extensively at GPC for short and medium distance serial communications and computer peripheral devices. This includes operator control stations and accessories, as well as CCTV camera controllers. All USB serial cables shall be factory made cables, which require no additional testing. USB to Ethernet converters (KVM switches) and USB extenders are used extensively in the CCR and Substations for remote operation of computer peripheral devices. Typically the maximum cable distance between a KVM switch or USB extender to a peripheral device is 35m.

7 Ethernet Network Topology

7.1 Control System Topology

The basic control system network topology consists of ControlLogix PLC's connected via an Ethernet/IP network. The control system consists of three independent network topologies to limit the broadcast domain. These broadcast domains are:

6.3.3.1.1.1.1 Unloading SCADA Network
6.3.3.1.1.1.2 Loading SCADA Network
6.3.3.1.1.1.3 Services SCADA Network

Within each of these functional domains are unitised PLC controllers. Each unitised PLC has a dedicated Ethernet LAN for PLC I/O, field devices, and protocol converters. In effect, the devices on an I/O network are governed by and only accessible to (from an operational perspective) the PLC to which that I/O network belongs. Eg: the weigher on a given conveyor is only accessible to that conveyor's PLC. In some instances, the use of ControlNet, DeviceNet, Modbus and Profibus Network protocols are utilised, which are discussed later in this standard.

Ethernet network segmentation involves the use of managed switches to split a larger collision domain into smaller ones in order to reduce collision probability, and to improve overall network throughput. The preference is for all Ethernet switches to be Managed Switches. A managed switch offers features including:

a) Spanning tree protocol (STP),
b) Port mirroring,
c) Bandwidth control,
d) Priority Ports,
e) IP clustering,
f) MAC address filtering,
g) Link aggregation,
h) Virtual LAN's (VLAN) etc.

The basic function of STP is to prevent bridging loops and the broadcast radiation that results from them. If an active link fails, STP also allows a network design to include backup links to provide fault tolerance.

A critical feature of a managed switch is that it permits Ethernet devices to have dedicated bandwidth on point-to-point connections to the network. For PLC-to-PLC direct communications, a full-duplex connection with only one transmitter and one receiver should be established, making the connection faster and more deterministic.

Link aggregation involves combining (aggregating) multiple network connections in parallel in order to increase throughput beyond what a single connection could sustain, with the benefit of providing redundancy in case one of the links should fail.

Configuration of VLAN's requires establishing partitions within a Managed Switch so that data can be transferred between unitised PLC networks. This is particularly critical for the "Services" equipment (dust suppression and lighting) which are shared between the Unloading and Loading systems. The VLAN enables data to be transferred via producer-consumer communications from one Unit PLC to another Unit PLC on separate LAN's without unnecessary data duplication. However, to retain the integrity of the unitised control system networks, the use of VLAN's shall be extremely limited.

7.2 Network Security

To prevent subversive or malicious attacks on the control system network, all PLC/SCADA network managed switches shall be secured using MAC address verification. This includes all servers, PLC processors and clients. Any attempt to access an Ethernet port on a managed switch without a registered MAC address shall generate a high priority alarm, and must be immediately investigated.

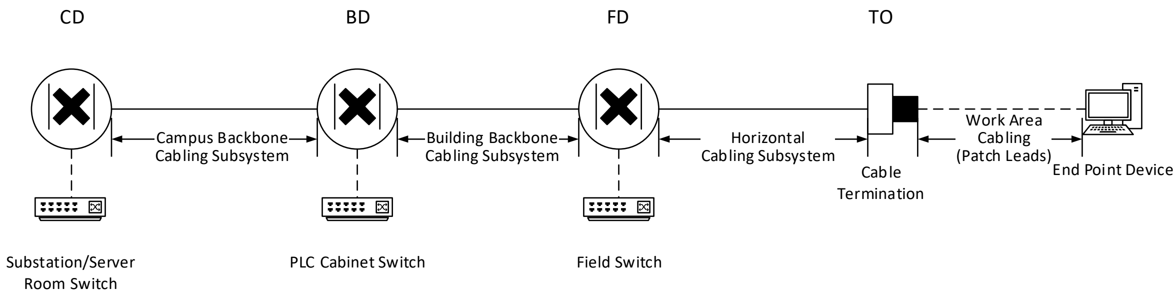
Using port mirroring, a managed Ethernet switches can create a mirror image of data that can go to an external device such as intrusion detection systems.

All network infrastructure shall be installed in secure areas (such as substations or lockable panels) that has restricted access to only qualified personnel. All wireless networks shall use WEP2 or WEP3 encryption where available.

There shall only be a single access point between the control system network and the corporate network protected by a firewall.

7.3 Ethernet Cabling Design

GPC uses the generic structured cabling subsystems as defined in AS/NZS:3080 Section 5.3.1. To ensure easy identification of components the diagram has been broken down below listing all the appropriate levels for a standard GPC conveyor control system installation using Australian standard terminology.



Note: see glossary at 1.1 for translation to local terminologies.

This standard is implemented (in several instances) at GPC in the form of distributed star topology networks. A series of high-speed switches are installed at all major substations and Server Rooms, forming a fault-tolerant ring as the backbone of the network. Each of these high speed switches in turn connect multiple branch-level switches, which extend the network down into each unit.

7.3.1 Backbone and Uplink Cabling

Backbone and uplink cabling refers to all cabling that is inter- or intra-buildings/cabinets but not to the final destination element. All backbone and uplink cabling shall be singlemode fibre optic. All cabling to/from a substation or building shall have a minimum of a 24core fibre cable installed. All field cabinet to field cabinet cabling should have a minimum of a 12core fibre cable installed. All field fibre-optic cabling should be single-mode. Any exceptions to this are subject to review and approval by the Process Control Superintendent and the Specialist Control Systems Engineer.

Multimode fibre may only be used in a composite cable if the specific application requires it.

Fibre optic cabling shall be designed with a minimum 50% spare capacity in all required grades of fibre.

All intra-FOBOT fibre patching connections shall use ST connectors.

Design Requirements	Product
19” Rack	1RU 24 Port FOBOT

7.3.2 Ethernet Horizontal Cabling

Horizontal cabling refers to cabling that is to individual outlets or final equipment elements. Horizontal cabling shall be either balanced twisted pair copper Cat-6A or Fibre Optic Singlemode OS1 Grade cable for all new installations. The selection of shield/unshielded and indoor/outdoor cable construction shall be based upon operational requirements and the detailed sections of this standard.

All horizontal cabling shall be installed and terminated to connectors located at the desired locations. Equipment is to be connected by factory made, tested and certified patch leads of the required length and standard. It is not acceptable to direct terminate plugs (eg RJ45) onto horizontal cabling. All horizontal cabling connectors are to be grouped into patch panels at the distribution point and outlets or patching enclosures (to maintain IP rating) at the device endpoint.

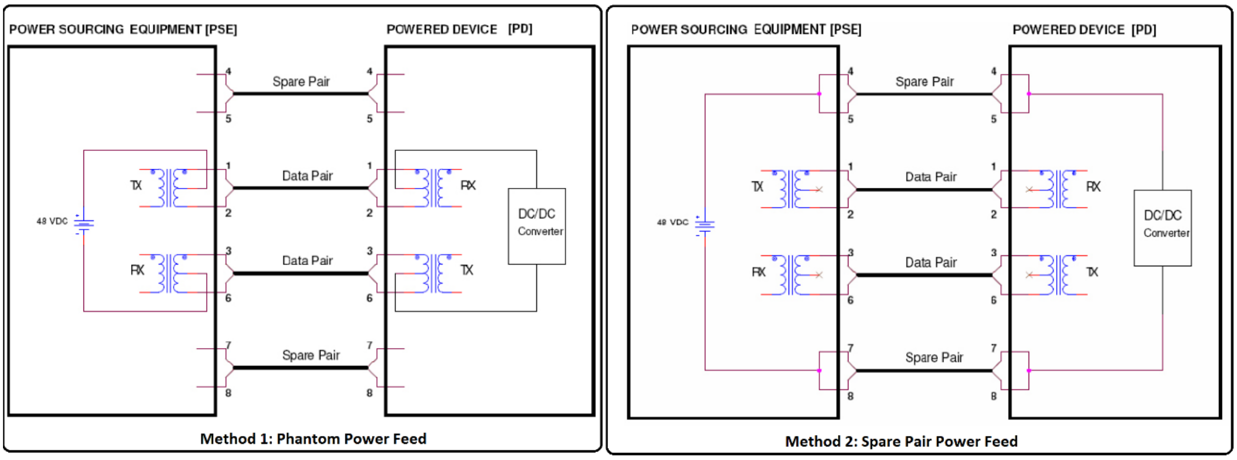
Horizontal patch panels shall meet the following requirements and selected from GPC’s preferred equipment list (GPC-ESS-203):

Design Requirements	Product
19” Rack	1RU 24 Port Patch Panel
Field Cabinet Main Distribution or MCC Comms Cell	DIN Rail Mounted 8 Port Patch Board
Field Cabinet End Point or MCC Cell Cable way	DIN Rail Mount Single RJ45 Socket
Field Instrument Termination	Posifit Junction Box and Cable Mount RJ45 Socket
Field Cabinet	Din Rail Mounted 12 port ST FOBOT or Wall-box FOBOT

7.4 Power Over Ethernet (POE)

All field-based network switches should have POE capabilities (IEEE 802.3) on at least some or all of the ports. This functionality offers a wider range of devices to be installed avoiding the costly requirement to install separate power to these field devices.

There are two different POE methods: Phantom Power and Spare-Pair power feed.



Phantom power can be used for four-wire or eight-wire cabling. For high power devices, pair 4/5 are used for the positive, and pair 7/8 for the negative. This does not apply to Gigabit Ethernet because all eight-wires are used for signal transmission so there are no spares.

The power limitations for POE are determined by the type of field device and the length of CAT-6 cable. Standard POE provides a minimum of 44Vdc (44V to 57V), and the power limitation are:

- Up to 12.0 watts (350mA) for Type 1 devices
- Up to 25.5 watts (600mA) for Type 2 devices
- Up to 55 watts (600mA per pair) for Type 3 devices
- Up to 100 watts (960mA per pair) for Type 4 devices

Several POE device used at GPC (such as the wireless router network) use 24Vdc instead of the nominal 48Vdc. Care must be taken to ensure compatibility and voltage drop are managed for each device.

7.5 Spare Hardware Capacity

For newly installed systems, the minimum network switch and cabling hardware spare capacity is 50%. In other words, a network switch connected with 12 x CAT-6 cables shall have a managed switch with a minimum of 18 ports.

8 Communication Protocols

8.1 Ethernet/IP Protocol

Ethernet is a family of frame-based, or data-packet-based, networking technologies that are part of the IEEE 802.3 standard. Ethernet/IP is an industrial protocol that operates over Ethernet, using the common industrial protocols (ControlNet, DeviceNet, Modbus-TCP). Ethernet/IP is an application-layer protocol, and it considers all of the devices on a network to be objects. Ethernet/IP is built on the standard TCP/IP stack, making it easy to connect plant floor data from controllers to enterprise servers running Ethernet TCP/IP. Ethernet/IP is designed for those control applications that can accommodate a measure of non-deterministic data transfer, but it is significantly more robust and deterministic than standard Ethernet and TCP/IP.

It could be said that "*any network can appear to be deterministic given sufficient bandwidth*". To maximise the deterministic nature of Ethernet, it is critical that the data bandwidth remains as low as possible.

GPC use two common application layer Ethernet protocols, namely OPC (OLE for Process Control) for standardised data reporting, and VPN (Virtual Private Network) for security. Both of these protocols (especially OPC) add a significant delay to the end-to-end transmission rates, and therefore need to be optimised to avoid reducing data transfer rates.

8.2 Equipment Addressing

The allocation of new IP addresses for the Site Control Network is managed by the GPC Control System Superintendent. Any changes to any control networks (including Ethernet, ControlNet, DeviceNet, and Modbus) shall be coordinated and approved through the GPC control systems team.

8.3 Wireless Ethernet Networks (WLAN)

Wireless Ethernet brings new issues of performance (collisions, unreliable communication, security, etc.) not seen with wired switched Ethernet. However, there is significant potential benefits of cost reduction and re-configurability provided by wireless which means that it should be considered for all new project developments.

Wireless Networks (WLAN) are based on IEEE 802.11 standards, and are often abbreviated as Wi-Fi. WLAN networks operate in both the 2.4 GHz and 5 GHz bands at a maximum data transfer rate of 600 Mbit/s. In recent years the 2.4 GHz band has become crowded with Bluetooth Devices and Microwave Transceivers. The 5 GHz band is wider than the 2.4 GHz band, with more channels, which permits a greater number of devices to share the space.

An access point can be either a *Main*, *Relay* or *Remote Base Station*. A main base station is typically connected to the wired Ethernet in a substation or the CCR. All base stations in a Wireless Distribution System must be configured to use the same radio channel, and share WEP keys or WPA keys if they are used (WEP3 is the preferred encryption method). A relay base station relays data between remote base stations, wireless clients, or other relay stations to either a main or another relay base station. A remote base station accepts connections from wireless clients and passes them to relay or main stations. Connections between "clients" are made using MAC addresses rather than by specifying IP assignments. GPC have setup an extensive wireless Ethernet network across site for the purpose of managing the dozer operations, and providing easy access for operators and maintenance personnel to critical control system data and alarms.

8.4 Modbus & Profibus Communications

There are multiple Modbus & Profibus communication networks still active at GPC. These include weighers, field instruments, power factor modules, water sprays, and wireless hand-held controllers.

The Modbus protocol uses a master–slave technique, in which only one device (the master) can initiate transactions. The slaves respond by supplying the requested data to the master. Modbus is supported on RS-232, RS-422, RS-485, Ethernet and other electrical standards. It should be noted that MODBUS RTU, MODBUS ASCII and MODBUS Plus are unique communication formats, and are not compatible with each other. The default baud rate for GPC is 9600, Even Parity, & 1 stop bit. The PLC is always set as the Master.

The preferred interface between Modbus (or Profibus) and a PLC controller is via a Digi One IAP module which converts Modbus to Ethernet/IP protocol.

The preferred migration path for all Modbus communications on site is towards Ethernet IP, which maintains the compatibility with the site-wide Ethernet network infrastructure. Profibus is used on site for interface with Siemens equipment, particularly in dust suppression, which are being phased out. No new equipment designed for use of site should use either Modbus or Profibus protocols.

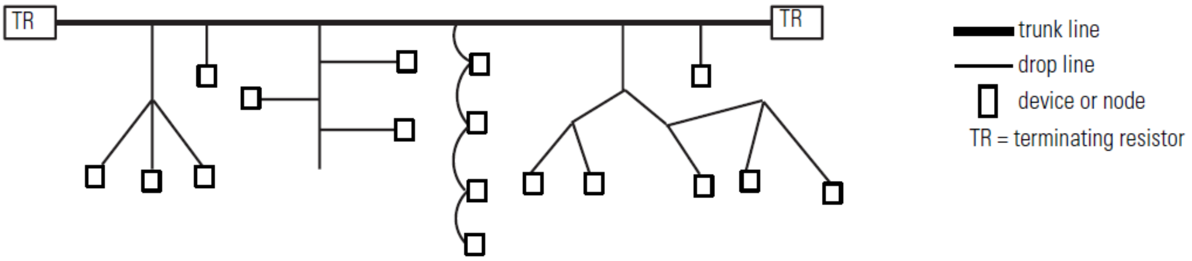
8.5 ControlNet Communications Network

ControlNet shall not be used for any installations in future.

8.6 DeviceNet Communications Network

DeviceNet is used at GPC at various locations including the Shiploader's and Dump Station's. DeviceNet, whilst still in service, shall not be used for future installations and only utilised where no alternative exists and approval is given by the GPC representative.

The DeviceNet cable system uses a trunk/drop topology.



DeviceNet is used for connection of field equipment into the PLC Control System. The round trunking cables (both thick and thin) contain five wires: One twisted pair (red and black) for 24V dc power, one twisted pair (blue and white) for signal, and a drain wire (bare). Drop cables contains four wires: One pair (red and black) for 24V dc power; one pair (blue and white) for signal.

The maximum number of nodes is 63, and the Baud rate is determined by the maximum trunk cable length between the terminating resistors. (*Note: The maximum cable distance is not necessarily the trunk length only, it is the maximum distance between any two devices.*) The maximum drop line length is 6m. Ensure that a 121 ohm (1/4 watt) terminating resistor is installed at each end of the trunk line, directly across the blue and white wires.

Data Rate	Maximum Distance (Flat Cable)	Maximum Distance (Thick Cable)	Maximum Distance (Thin Cable)
125k bits/s	420m	500m	100m
250k bits/s	200m	250m	100m
500k bits/s	75m	100m	100m

A bus-extender module can be added to a DeviceNet network to extend the length of the network and allow longer drop-line lengths. Use only Rockwell manufactured or approved cables, connectors and power supplies for all DeviceNet networks.

DeviceNet networks with long trunk lines or with devices that draw large currents at a long distance sometimes experience difficulty with common mode voltage. If the voltage on the black V- conductor differs by more than 4.65V from one point on the network to another, communication problems can occur. Moreover, if the voltage between the black V- conductor and the red V+ conductor ever falls below 15V, then common mode voltage could adversely affect network communication. To work around these difficulties, add an additional power supply or move an existing power supply closer to the heavier current loads. Ground the V- conductor, shield, and drain wire at one place only. Do this at the power supply connection that is closest to the physical centre of the network to maximize the performance and minimize the effect of outside noise.

9 Network Design Considerations

9.1 Power Quality and RFI Filtering

All control critical and control supervisory communications equipment shall be powered from a UPS with telecommunication grade line filtering. The control system and network UPS power supplies shall energise equipment for a minimum of 1 hour in the event of mains power failure. The effect of power quality on the network power supplies shall be mitigated through the application of RFI filters, surge protection, power conditioning devices, mechanical shielding and telecommunication-grade power filters.

9.2 Redundancy

The inclusion of redundant network components contributes to increased process availability, but at an increased cost. Therefore control system redundancy should be applied only in areas of importance with respect to availability. The GPC philosophy is that "*Network hardware redundancy is required where a single point of equipment or infrastructure failure will cause the process to be unavailable for an unacceptable period of time.".* Redundancy can be applied to communications transmitting/receiving equipment (node), or to the communications medium (path). The redundancy can be via local duplication of the nodes and path, or making the duplication geographically dispersed. Control critical and supervisory network communications protocols shall support self-healing redundant topology. The ability to recover from a network fault by hot swapping equipment may form part of a risk mitigation strategy that may remove the necessity for redundancy. The review must include the time taken for a person to arrive at the fault, with the appropriate spares, and perform the repair. Pre-configured hot-swappable network switches are critical to reduce production downtime.

As process control environments have requirement high frequency repeat packet intervals and limited tolerance to lost packets, overheads for redundancy mechanisms need to less than 100ms to minimise effects on automation devices using the network. GPC currently uses MRP on Hirschmann networks, and REP for Cisco networks onsite for campus level (backbone) fault tolerance.

The critical requirement for high process availability at the RGTCT requires that the network be designed such that a disruption to normal control system operations only has a limited and localised effect on process availability. This shall be achieved through segmentation of the network infrastructure. The distribution of these resources based on plant assets allows a level of local control autonomy for the plant asset. In the event of a communications failure, the local processor shall be able to put the plant asset into a safe state.

9.3 Equipment Specification

The correct specification of network equipment can have a significant impact on process availability at RGTCT. Networking equipment and infrastructure shall be specified to suit the harshest environmental conditions likely to occur on the site. Radio Frequency Interference (RFI) is a significant risk, and all equipment shall be compliant with EN61000-6-2 *Generic Immunity Standard Part 2*.

The specification of network components shall ensure suitability for:

a) Environmental operating ranges including Temperature, Humidity and Dust.
b) Vibration and Shock Resistance
c) EMC compliance for Emission and Immunity
d) Enclosure requirements for IP protection rating and RFI/EMI shielding.
e) Cable shielding, protection and termination.

Equipment listed in GPC Site Standard GPC-ESS-203 - Preferred Equipment List shall be chosen wherever possible to maintain standardisation of equipment and proven compliance to the specified environmental operating conditions.

10 Appendices

10.1 Appendix 1 – References and Related Documents

All equipment, work and installations shall, as a minimum, comply with latest revisions and amendments of the following Acts, Regulations, Codes and Standards.

10.1.1 Acts and Regulations

All electrical design shall comply with:

- Queensland Electrical Safety Act.
- Queensland Professional Engineers Act.
- Queensland Electrical Safety Regulation.
- Queensland Work Health and Safety Act.
- Queensland Work Health and Safety Regulation.

10.1.2 Code of Practice

All electrical design shall comply with:

- The Queensland Electrical Safety Codes of Practice

Australian and International Standards

10.1.3 Gladstone Ports Corporation Documents

The following documents relate to this Engineering Site Standard:

Standard	Title
Design and Installation Standards	
GPC-ESS-200	Electrical Design Criteria.
GPC-ESS-201	Electrical Design (This standard).
GPC-ESS-202	Electrical and Instrument Installation.
GPC-ESS-203	Electrical, Instrument and Control Preferred Equipment
GPC-ESS-204	Electrical Drafting, Drawing and Naming Requirements
GPC-ESS-205	Identification Labels and Signs.
HV Equipment and Installation Standards	
GPC-ESS-300	HV Installation and Equipment Testing.
GPC-ESS-301	High Voltage Switchgear.
GPC-ESS-302	Power Transformers Including Pad Mount Transformers.
GPC-ESS-303	HV Squirrel Cage Induction Motors.

Standard	Title
GPC-ESS-304	High Voltage Variable Voltage Variable Frequency Drives
GPC-ESS-305	Earthing Resistors and Reactors
LV Equipment and Installation Standards	
GPC-ESS-400	Electrical Cables Installation.
GPC-ESS-401	Electrical Cables.
GPC-ESS-402	LV Squirrel Cage Induction Motors
GPC-ESS-403	Generators.
GPC-ESS-404	Low Voltage Motor Control Centres.
GPC-ESS-405	Electrical Distribution Boards.
GPC-ESS-406	Enclosures for Electrical Equipment.
GPC-ESS-407	Battery Backed and Uninterruptable Power Supplies.
GPC-ESS-408	Portable Electrical Equipment.
GPC-ESS-409	Lighting.
GPC-ESS-410	Electrical Earthing and Lightning Protection.
GPC-ESS-411	Temporary Electrical Installations.
GPC-ESS-412	Testing and Commissioning of Electrical Equipment.
GPC-ESS-413	Hazardous Areas Installations.
GPC-ESS-414	Fire Detection and Alarm Systems.
GPC-ESS-415	Low Voltage Variable Speed Drives.
GPC-ESS-423	General Requirements for Electrical Switchrooms.
GPC-ESS-424	Electrical Requirements for Demountable Transportable & Prefabricated Buildings.
Instrument, Control and Communication Standards	
GPC-ESS-502	PLC Programming.
GPC-ESS-503	SCADA Programming.
GPC-ESS-504	Communications.
GPC ESS-505	CCTV and Security
GPC-ESS-508	Control Systems Tag Naming.

Standard	Title
GPC-ESS-510	Functional Safety Standard - Functional Safety Management Plan.
General Standards	
GPC-GSS-001	Site Information
GPC-GSS-004	Manufacturer's Data Report (MDR)
GPC-GSS-006	Preparation of Operation & Maintenance Manuals
GPC-GSS-007	Packaging, Transport and Delivery of Goods

10.1.4 Australian Standards

All methods, procedures, components and equipment shall comply with the latest revision of the relevant Australian Standards or in the absence of appropriate Australian Standards with relevant IEC or International Standard, including those listed below, together with the requirements of competent authorities having jurisdiction over all or part of the manufacture, installation or operation of the equipment, except where modified by this standard.

Where conflict exists between this standard and other requirements, the most stringent requirement shall be satisfied. All such conflicts shall be brought to the attention of the Superintendent. The Superintendent shall make the final decision on all matters of a technical nature.

Unless otherwise noted Australian Standards shall take precedence over International Standards.

Australian Standard	Title
AS/NZS:1768	Lightning and Surge Protection
AS/NZS:3000	Australian Standard - Wiring Rules
AS/NZS:3080	Australian Standard - Information technology - Generic Cabling for Commercial Premises
AS/NZS:3085.1	Telecommunications Installations – Administration of Communications Cabling Systems
AS/NZS:4262.1	Telecommunication Overvoltages - Protection of Persons
AS/NZS:4262.2	Telecommunication Overvoltages - Protection of Equipment
AS/NZS:7799	Information Security Management
AS/NZS:14763.3	Australian Standard – Information Technology – Implementation and Operation of Customer Premises Cabling – Part 3.

Australian Standard	Title
AS/NZS:60529	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS:60793	Optical Fibres – Measurement & Test Procedures
AS/NZS:60794	Optical Fibres – Sectional Specification
AS/NZS:61935	Australian Standard – Specification for the Testing of Balanced and Coaxial Information Technology Cabling
IEC 61156	Multicore Cables for Digital Communications
IEC 61754	Fibre Optic Connector Interfaces

10.2 Appendix 2 – Revision History

Version Number	Revision date	Revision description	Author	Endorsed by	Approved by
	12/01/21	Issued for use	Jeff Pajonk, Specialist Electrical & Instrumentation Engineer	Scott O'Brien, Electrical Engineering Superintendent	Scott O'Brien, Electrical Engineering Superintendent