ElectraNet

Operational Technology General Requirements

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1. Purpose

This document describes the requirements for operational technology services that form part of ElectraNet's South Australian telecommunications network.

2. Scope

This specification is applicable to telecommunications services that are to be are to be installed in ElectraNet substations or telecommunications sites.

3. Products, terms and acronyms

3.1 Products

Term	Definition
Pathloss	Is a software application for microwave radio link design and planning. Pathloss is a product of Contract Telecommunication Engineering Ltd. Further information is availible at: https://www.pathloss.com/.

3.2 Terms

Term	Definition
99.9%	Is also expressed as ‘three nines’. It represents a characteristic of system performance that allows for system downtime of approximately 8.77 h/year.
99.97%	Represents a characteristic of system performance that allows for system downtime of approximately 2.63 h/year.
99.98%	Represents a characteristic of system performance that allows for system downtime of approximately 1.75 h/year.
99.99%	Is also expressed as ‘four nines’. It represents a characteristic of system performance that allows for system downtime of approximately 52.60 min/year.
99.999%	Is also expressed as ‘five nines’. It represents a characteristic of system performance that allows for system downtime of approximately 5.26 min/year.
Availability	Ability to be in a state to perform as required.
Bandwidth	Is the width of a frequency band over which a given characteristic of the transmission channel does not differ from its reference value by more than a specified amount or ratio *Note: The given characteristic can be, for example, the amplitude/frequency characteristic, the phase/frequency characteristic or the delay/frequency characteristic.*
Cat 5	Category 5 cable is a twisted pair cable for computer networks. The cable standard provides performance of up to 100 MHz and is suitable for most varieties of Ethernet over twisted pair up to 2.5GBASE-T but more commonly runs at 1000BASE-T (Gigabit Ethernet) speeds.
Contractor	Is a person bound to carry out and complete works under contract.

Term	Definition
Customer	Is a person who intends to establish or modify a connection to ElectraNet's transmission network who is not a third party IUSA provider.
Designer	Is a Contractor who designs the workings of something for ElectraNet prior to it being implemented, by preparing drawings or plans.
E1	E1 is a common carrier-provided point-to-point digital line service used in private data networks and cellular, Wi-Fi and fixed-network backhaul. An E1 service delivers 2.048 Mbps capacity that can be split into multiple 64 Kbps channels and is typically charged by distance.
Ethernet	Is the LAN technology that specifies the standard technical specifications of hardware for connectivity. The Ethernet standards are governed by the IEEE 802 series and vary with cabling distance and transfer speed.
Functional location	Is an organisational unit that structures the maintenance objects for ElectraNet, according to functional, process-related, or spatial criteria. A functional location represents the place at which a maintenance task is to be performed.
Jitter	Is set of short-term non-cumulative variations in the significant instants of a digital signal from their ideal positions in time
Krone module	Is an insulation-displacement connector for telecommunications.
Krone termination frame	Is a frame for the mounting of Krone modules.
Latency	Time interval between an input and a response.
Redundancy	Provision of more than one means for performing a function
third party IUSA	Is defined in the National Electricity Rules as, those contestable IUSA components of an identified user shared asset that are not, or will not be, owned or leased by the Primary Transmission Network Service Provider.

3.3 Acronym or initialism

Acronym or initialism	Definition
AC	Alternating Current, is periodic electric current with negligible direct component.
ACMA	Australian Communications and Media Authority, is an independent Commonwealth statutory authority responsible for the regulation of broadcasting, radiocommunications, telecommunications and online content.
ADM	Add/Drop Multiplexer, is a device is a device that can add one or more lower-bandwidth signals to an existing high-bandwidth data stream, and at the same time can extract or drop other low-bandwidth signals, removing them from the stream and redirecting them to some other network path.
AEMC	Australian Energy Market Commission, is an independent Commonwealth statutory authority responsible for the regulation of Australian electricity and gas markets. The AEMC publishes the National Electricity Rules.
AEMO	Australian Energy Market Operator, manages electricity and gas systems and markets across Australia.

Acronym or initialism	Definition
AER	Australian Energy Regulator, is constituent part of the Australian Competition and Consumer Commission (ACCC). It is an organisation that regulates wholesale and retail energy markets, and energy networks, under national energy legislation and rules.
BER	Bit Error Rate (in telecontrol), the ratio of the number of bits received inverted to the total number of bits sent.
BISO	Bringing-Into-Service Objective, is a limit set for digital paths, sections, and transmission systems to achieve the: ▪ error performance ▪ timing performance ▪ availability objectives for given for a multiservice environment.
CCM	Communications Cabling Manual (Volumes 1 and 2), are compiled by Standards Australia and provide information to the communications cabling industry.
CIR	Committed Information Rate, is the guaranteed rate at which a Frame Relay network will transfer information under normal line conditions.
DC	Direct Current. Is an electric current that is time-independent.
DNA	Designated Network Asset, as defined in the NER as; The apparatus, equipment, plant and buildings that: (a) are used from the boundary point to convey, and control the conveyance of, electricity, for an identified user group; (b) are for the exclusive use of the identified user group and may be owned by different persons within that identified user group; (c) include power lines that have a route length of: (i) 30 kilometres or more; or (ii) less than 30 kilometres where the owner of those assets has entered into a network operating agreement in respect of those assets; and (d) do not: (i) provide prescribed transmission services; (ii) form part of a network loop; (iii) form part of a transmission system for which a Market Network Service Provider is registered under Chapter 2; or (iv) form part of a declared transmission system of an adoptive jurisdiction.
DNP3	Distributed Network Protocol 3, is a set of communications protocols used between components in process automation systems.
ETCDB	ElectraNet Telecommunications Configuration DataBase, is a database used by ElectraNet for the management of telecommunications configurations data.
FAT	Factory Acceptance Testing, is the inspection and static or dynamic testing of systems or major system components to support the qualification of an equipment system conducted and documented at the supplier site or facility.

Acronym or initialism	Definition
FLHIA	Functional Location Hazard Identification and Assessment, is a document for hazard identification, risk assessment and control that manages safety hazards at a particular functional location.
FunLoc	Functional Location, has the same meaning as functional location.
HF	High Frequency, is a frequency above 9 kHz.
HMI	Human Machine Interface, is an interface between operating staff and the instrumentation and computer systems to the plant.
HSB	Hot Stand-By, is a method for making sure that systems continue to work, uninterrupted, when one or more of its components fail.
HSM	High Speed Monitoring, is a system developed by AEMO to for NEM-wide high-speed monitoring system that would complements AEMO's oscillatory stability monitoring capability.
IETF	Internet Engineering Task Force, is a standards organisation for the Internet and is responsible for the technical standards that comprise the Internet protocol suite (TCP/IP).
IP	Internet Protocol, is a protocol for connectionless transmission that corresponds approximately to a protocol within the network layer of the OSI reference model.
IP/MPLS	Internet Protocol/Multi-Protocol Label Switching, is a routing technique in telecommunications networks that directs data from one node to the next based on labels rather than network addresses.
ITP	Inspection and Test Plan, is a document that identifies the items of materials and work to be inspected or tested, by whom and at what stage or frequency, as well as hold and witness points, references to relevant standards, acceptance criteria and the records to be maintained.
IUSA	Identified User Shared Asset, as defined in the NER as: The apparatus, equipment, plant and buildings that: (a) are used for the purpose of: (i) connecting a person through a dedicated connection asset to a transmission network, or (ii) expanding the existing transmission network to incorporate a designated network asset (but does not include subsequent components that are incorporated into that designated network asset) (b) are not for the exclusive use by that person for a dedicated connection asset or identified user group for a designated network asset (c) if used to connect that person to a transmission network through a dedicated connection asset, under normal operating conditions, cannot be electrically isolated from the transmission network without affecting the provision of shared transmission services to other persons (d) are not part of the declared transmission system of an adoptive jurisdiction or a designated network asset.
LAN	Local Area Network, is a computer network located on a user's premises within a limited geographical area.

Acronym or initialism	Definition
LoS	Line-of-Sight, is the straight path between a transmitting antenna and a receiving antenna when unobstructed by the horizon.
LSA	Loud Sounding Alarm, is an alarm that generates an audible noise that alerts personnel within the vicinity that the alarm has been triggered.
LSPM	Light Source and Power Meter, is a test device comprising of 2 pieces of test equipment that measure fibre-optic light continuity, loss, and the strength of the optical signal.
MSP	Maintenance Service Provider, is an organisation that is contracted to provide routine or periodic maintenance activities.
MTU	Maximum Transmission Unit, is the size of the largest Protocol Data Unit (PDU) that can be communicated in a single network layer transaction.
NER	National Electricity Rules, are rules made under the national electricity law and govern the operation of the NEM.
NEM	National Electricity Market, is a wholesale market through which generators and retailers trade electricity in Australia. It interconnects the 6 eastern and southern states and territories.
OHS	Occupational Health and Safety, is concerned with protecting the safety, health and welfare of people engaged in work or employment.
OPAX	Operational Private Automatic eXchange, is the infrastructure and services for secure ElectraNet telecommunication.
OPGW	Optical Ground Wire, is a type of conductor that is used in overhead power lines that combines the functions of earthing and communications.
OpsWAN	Operational Wide Area Network, is a data communications network that enables communication between ElectraNet's offices, remote substations, and telecommunications sites.
OT	Operational Technology. is hardware and software that detects or causes a change, through the direct monitoring and/or control of industrial equipment, assets, processes, and events.
OTDR	Optical Time Domain Reflectometer, is an optoelectronic instrument used to characterise an optical fibre.
PDH	Plesiochronous Digital Hierarchy, is a technology used in telecommunications networks to transport large quantities of data over digital transport equipment such as fibre optic and microwave radio systems.
PLC	Power-Line Carrier, is a communications path that transfers data on a conductor that is also used simultaneously for conduction high voltage power.
PSDCS	Power System Data Communication Standard, is a standard published by AEMO that is made under clause 4.11.2(c) of the National Electricity Rules.
PSN	Packet Switched Network, is a type of computer communications network that groups and sends data in the form of small packets.
PSTN	Public Switched Telephone Network, is the infrastructure and services for public telecommunication.

Acronym or initialism	Definition
PV	Photovoltaics, convert light into electricity using semiconducting materials that exhibit the photovoltaic effect
RF	Radio Frequency, are electromagnetic waves ranging from 9 kHz to 60 GHz.
SAP	Systems, Applications and Products, a software application used by ElectraNet for asset management functions.
SAT	Site Acceptance Testing, is the inspection and static or dynamic testing of systems or major system components to support the qualification of an equipment system conducted and documented at an ElectraNet site.
SCADA	Supervisory Control And Data Acquisition, is the monitoring and remote control of equipment from a central location using computers.
SDH	Synchronous Digital Hierarchy, is a standardised protocol for multiplexing technology that is used in the telecommunications for the transfer of multiple digital bit streams synchronously over optical fibre.
SiD	Safety in Design is a system to document a process demonstrating systematic safety risk management.
SMSC	System Monitoring and Switching Centre, are the facilities used by ElectraNet for managing the South Australian transmission system.
SNR	Signal-to-Noise Ratio, also known as S/N, is a measure used to compare the level of a desired signal to the level of background noise.
STM-1	Synchronous Transport Module level-1, is the SDH ITU-T fibre optic network transmission standard. It has a bit rate of 155.52 Mbit/s.
TCA	Transmission Connection Agreement, a connection agreement made between ElectraNet and a Registered Participant that contains the specific conditions for connection and access to the transmission network.
TNCP	Transmission Network Connection Point, as defined in the NER as: A connection point on a transmission network.
UV	Ultraviolet, is a form of electromagnetic radiation with wavelength from 10 nm to 400 nm
WAN	Wide Area Network, is a network that provides communication services to a geographic area larger than a single area.

4. Operational technology requirements

4.1 Operational technology overview

The substation OT deployment comprises of the infrastructure, systems and services required to provide secure, resilient, and reliable communication and information services as required by the NER and interpreted by the PSDCS and by ElectraNet for safe, secure, and reliable electricity network operations and maintenance.

4.1.1 Components

1. The operating technology deployment at a substation comprises of the following equipment and infrastructure as required:
    a. Dedicated building, nominally a transportable, which contains the OT assets, including dedicated -48 V DC power supplies.
    b. Inter-site bearers (optical or microwave) and associated infrastructure, for example a radio tower for microwave bearers, pit/pipe underground infrastructure for optical fibre bearers, etc.
    c. Wide area network equipment (including multiplexers, routers, and switches).
    d. Local area equipment (including IP switches, Wi-Fi access point).
    e. Telephony equipment (including handsets and external loud sounding alarms).
    f. Telemetry assets including, SCADA gateway, power quality monitors, weather monitors, pollution monitors, etc. as required.
    g. Cyber-security equipment.
    h. Site server for engineering management and HMI.
2. Telecommunications equipment must be selected from the approved equipment list detailed on 519 STD/0N1-001.

4.1.2 Approved service catalogue

Services must meet or exceed to the minimum performance standards detailed in:

1. Table 1: Regulatory data service
2. Table 2: Operational data services
3. Table 3: Other data services

Table 1: Regulatory data service

Regulatory data service	Minimum performance standard		Source of requirement
Protection: [X + Y], incl sever trips	Availability	99.9% (per path)	▪ NER, Schedule 5.1, clause S5.1.2.1 (d) ▪ NER, Schedule 5.1, clause S5.1.9 (c) and (d) ▪ NER, Schedule 5.1a, Table S5.1a.2
	Redundancy	Yes (physical and logical path)	
	Jitter	< 1 ms from relay to relay	
	Data Payload	64 kb	
	Latency	Real time, 5-15 ms	
	Bandwidth	64 kbps (as real time)	
	Protocols	C37.94	
SCADA	Availability	99.97%	▪ PSDCS 2.3 ▪ PSDCS 3.1, Table 3 ▪ PSDCS 3.2
	Redundancy	Sufficient redundancy	
	Data payload	64 kb	
	Latency	Near real time, less than 1 s	
	Bandwidth	64 kbps	
	Protocols	DNP3 over IP	
Control run back scheme: [X + Y]	As per SCADA requirement		TCA with Customers
Voice: [‘on network’ + ‘off network’]	Availability	99.9% (per path)	▪ NER, clause 4.11.2 (a) ▪ NER, clause 4.11.3 (c) ▪ Industry ‘best practice’ ElectraNet OHS
	Redundancy	Yes (physical and logical path)	
	Data payload	64 kb per voice service	
	Latency	Real time	
	Bandwidth	128 kbps (as real time)	
	Protocols	IP	

Table 2: Operational data services

Operational data services	Minimum performance standard		Source of requirement
High speed monitoring	Availability	99.97%	HSM (AEMO)
	Redundancy	Sufficient redundancy	
	Data payload	64 kb	
	Latency	Near real time, less than 4 s	
	Bandwidth	64 kbps	
	Protocols	DNP3 over IP	
Power system fault restoration (during outage)	Availability	99.98%	Internal: Fault understanding within 1 h
	Redundancy	No, but required to meet availability	
	Data payload	100 kb to 100 Mb or greater	
	Latency	Not real time	
	Bandwidth	2 Mbps	
	Protocols	IP	
Power system fault analysis (post event)	Availability	Best efforts	Internal
	Redundancy	No	
	Data payload	100 kb to 100 Mb or greater	
	Latency	Not real time	
	Bandwidth	Best efforts	
	Protocols	IP	
Substation remote configuration management	Availability	As above	Internal
	Redundancy	As above	
	Data payload	As above	
	Latency	As above	
	Bandwidth	100 kb to 1 Mb	
	Protocols	IP	
Substation remote condition monitoring	Availability	As above	Internal
	Redundancy	As above	
	Data payload	As above	
	Latency	As above	
	Bandwidth	10 kb to 100 kb	
	Protocols	IP	

Table 3: Other data services

Other data services	Minimum performance standard		Source of requirement
Dynamic Rating (including weather stations)	Availability	NA, fall back to static ratings.	Internal
	Redundancy	No	
	Data payload	10 kb to 100 kb	
	Latency	Near real time, less than 4 s	
	Bandwidth	64 kbps	
	Protocols	IP	
Surveillance (video and perimeter security)	Availability	99.9%	Internal
	Redundancy	No, but required to meet availability	
	Data Payload	2-20 Mb or greater	
	Latency	Real time	
	Bandwidth	12 Mbps	
	Protocols	IP	
Security: building and fire, Cyberkeys	Availability	99.9%	Internal
	Redundancy	No, but required to meet availability	
	Data Payload	64 kb	
	Latency	Real time	
	Bandwidth	64 kbps	
	Protocols	IP	
Situational awareness (OpsWAN cameras)	Availability	Best endeavours	Internal
	Redundancy	No	
	Data Payload	1 Mb	
	Latency	Real time	
	Bandwidth	1 Mbps	
	Protocols	IP	
Construction and maintenance communications	Availability	Best endeavours	Internal
	Redundancy	No	
	Data Payload	100 Mb	
	Latency	not real time	
	Bandwidth	10 Mbps	
	Protocols	IP	

4.1.3 Bandwidth required per substation

The combined bandwidth requirement for all services detailed in:

1. Table 1: Regulatory data service
2. Table 2: Operational data services
3. Table 3: Other data services

is 25 Mbps, per substation. An additional 2 Mbps is required for OT network performance management, producing an overall bandwidth of 27 Mbps per substation.

4.1.4 Service performance

1. Since the overall OT network is made up of a series of links, the end-to-end network availability must always be less than that of the individual links. Therefore, the individual link availability required is extremely high. In many cases this can only be achieved via either equipment and/or path diversity. protection, SCADA, telephony, and power system fault restorations services can only achieve the availability standards required if an alternate path is provided. As per:
    a. Table 1: Regulatory data service
    b. Table 2: Operational data services
    c. Table 3: Other data services
2. The bandwidth required for the alternate path is 2.25 Mbps per substation.
3. In addition, the services that need to be carried impose several strict requirements on the underlying OT network in relation to:
    a. Latency: the time required for the entire payload to get to the other end. This is a function of the available bandwidth, packet length, the transmission medium, and the processing speed of intermediate and terminal equipment.
    b. Jitter: the variability in the latency between successive payload transmission
    c. Availability: the ratio of the time a system or component is functional to the total time it is required or expected to function.
4. These performance requirements impose limitations on the OT bearer options available at the substations. For more details on the protection system requirements refer to 1-09-FR-01.
5. All services must meet the performance requirements as per IEEE Std 1646.

4.1.5 Bearer options

1. To meet the performance requirement for the carriage of regulated services (AER and AEMO services), ElectraNet will need to provide 2 high-speed bearers.
2. However, since new substations break into the existing network, the bearer also needs to carry traffic required for other substations further out in the network. As a result, these bearers also need to be high capacity.
3. The preferred solution is to install 2 fibre bearers. This is reasonably cost effective to do, especially on the 275 kV transmission network as most of the lines have OPGW installed already. Where this is not possible, the next preferred solution is a one fibre bearer and one radio, or possible 2 radio bearers. In all cases, the lowest long run cost option (low levels of ongoing operations, maintenance, and replacement costs) must be chosen.

4.2 Operational technology general requirements

1. ElectraNet must provide and maintain communications facilities as required by the AEMC, NER and interpreted by the AEMO Standard PSDCS.
2. This section details the general requirements as applicable to all the various assets and component that make up the OT deployment at a substation. Some assets have additional specific requirements, and they are highlighted specifically within subsections under the general sections below.

4.2.1 Safety and environmental requirements

1. All equipment, devices and components for the ElectraNet OT Network must be suitable for sale and use in Australia, meeting all regulatory and legislative requirements.
2. These include, but are not limited to:
    a. AS/NZS 3000
    b. AS/CA S009
    c. AS/NZS IEC 60825.2
    d. Radiocommunications Act 1992, Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2014
3. Contractor (and subcontractor) access to all ElectraNet sites must be pursuant to the rules, conditions and requirements as detailed in the 1-07-M06.
4. The Designer must implement SiD activities in accordance with 1-16-OP01-P013.
5. In support of achieving SiD, the detail design process must also comply with the requirements of 1-16-OP01-P014.
6. The appropriate level of supervision must be provided to meet the requirements of the work, especially within the substation environment that requires specialised work practices.

4.2.2 Planning and design requirements

1. The primary planning requirement is to ensure there is no common point of failure along any of the communication path between the equipment that carries the Set X line protection and the Set Y line protection. Further, this diversity and redundancy requirement is also extended to the main and backup SCADA services and the main and backup telephony services, including for the revenue and check metering services.
2. This requires the provision of 2 separate suites of OT equipment within the site, separate and physically diverse bearers leaving the site, and separate and diverse routing along the intra-site optical and copper cables within the site.
3. It also requires that equipment must be powered via dual -48 V DC power supplies. Equipment that requires 110 V DC must be powered by a 48 to 110 V DC-DC converter.
4. All equipment for the ElectraNet OT Network should be suitable for use in a power utility substation environment.
5. These include, but are not limited to
    a. IEEE Std 1613.1
    b. IEC 61850 (series)
    c. EN 300 462 (series)

d. ETS 300 147
e. ETSI ETR 241
f. ISO/IEC 11573
g. ISO/IEC 11801
h. ITU-T G.652
i. ITU-T G.702
j. ITU-T G.703
k. ITU-T G.704
l. ITU-T G.707
m. ITU-T G.711
n. ITU-T G.723
o. ITU-T G.783
p. ITU-T G.811
q. ITU-T G.957
r. RALI FX3

6. All ElectraNet OT Network planning and design work must be done within the ETCDB.
7. In addition, all equipment must be able to be fully integrated into ElectraNet's existing OT network management systems.

4.2.2.1 Point-to-point radio systems

1. All single bearer ElectraNet microwave radio links must be 1+1 HSB hardware configuration. All multiple bearer ElectraNet microwave radio links must be an N+1 protected hardware configuration. All ElectraNet microwave radio links must have a validated minimum fade margin of 30 dB.
2. Point-to-point radio links are affected by environmental (climatic/atmospheric) influences; thus, the design of point-to-point microwave radio systems must comply with and meet the reliability and availability standards imposed by ElectraNet's operational requirements.
3. The point-to-point radio link design must:
4. Apply an accurate representation of the actual path's characteristics.
5. Path engineering to meet the minimum clearance criteria and to determine the risks and effects of possible RF signal disturbance (e.g., reflection, refraction, diffraction, etc.).
6. Link engineering to model the specific radio equipment feeder cables and antennas to accurately determine the fade margin and associated link availability.
7. Desktop studies only provide a useful indication that a radio link path may be suitable. A LoS survey must be conducted to verify and confirm the path validity of all new radio links (particularly the identification of localised obstacles that may impinge into the radio LoS).
8. Telecommunications industry standard radio path software planning tools such as Pathloss or T-Path must be used for desktop radio link design analysis.
9. The radio designer must be competent with radio propagation theory and calculation methodology for determination of the radio link performance and path losses.

4.2.2.2 Optical fibre cables

The standard minimum specification for inter-site optical fibre cable must be single mode in compliance with ITU-T G.652. The standard minimum specification for intra-site (i.e., between buildings at a substation site) optical fibre cable must be 850 nm multimode in compliance with ISO/IEC 11801.

4.2.2.3 Digital line terminating equipment

1. SDH ADMs must be utilised as digital line terminating equipment entities for both optical and radio based SDH links.
2. All optical links must have their optical link budget determined and strictly adhered to.
3. Optical links must be dual fibre (core) arrangement.

4.2.2.4 IP network equipment

1. IP/MPLS label switching routers must be used as terminating equipment entities for optical and radio based packet switched links.
2. LAN switching equipment must be used for terminating local and remote services.
3. Optical links must have their optical link budget determined and adhered to.
4. Optical links must be dual fibre (core) arrangement.

4.2.2.5 Power line carrier systems

1. PLC systems must:
    a. only be deployed where no other reasonable option exists.
    b. when used, only be used for a secondary bearer.
2. When implementing PLC systems:
    a. Only analogue PLC systems must be deployed within the ElectraNet powerline transmission network. Digital PLC systems have been experimented with, but their operational performance attributes have been found unsatisfactory within the South Australian environment (in which the ElectraNet powerline transmission network operates), thus must not be deployed within the ElectraNet powerline transmission network.
    b. The Power Line Carrier system's carrier frequencies can be reused throughout the ElectraNet powerline transmission network, if PLC systems using the same carrier frequencies are isolated sufficiently; namely; by 2-line section or one line section and a transformer.
    c. The PLC system must be phase to phase coupled to 2-phases of the powerline. Phase to earth coupling must not be used for either single or multiphase coupling of PLC systems.
    d. For 132 kV powerlines, the PLC systems must be 2-phase coupled to the R and S phases.
    e. The PLC system may be coupled to 3 phases of the powerline under special applications that require lower attenuation than can be provided by 2-phase coupling.
    f. PLC systems must be provided with 2 4 kHz channel payload capability.
    g. All protection signals carried over the PLC system must employ 2 contra-shifting dual tone frequency shift modulation schemes.

4.2.2.6 Network synchronisation

1. In accordance with ITU-T G.822 and ISO/IEC 11573, in the event of a major fault event within the Synchronisation network (e.g., link or device failure), the fault tolerance/overall timing stability of the OT Network must not exhibit any significant degradation or adverse effects.
2. The synchronisation distribution must be arranged so that when a failure occurs that isolates a section of the synchronisation network from the main synchronisation network, one network element will become a ‘section master clock’ and all other network elements in the isolated domain will synchronise from the ‘section master clock’ until the network fault is corrected, and the overall Synchronisation network restored into operation.

4.2.2.7 DC power supply -48 V DC

The DC power supply systems should meet technical requirements specified in 1-09-FR-25 with the following exceptions.

4.2.0.1 Supply system requirements

1. Each Telecommunication building must be provided with redundant DC supplies, fully duplicated to provide supply availability of 99.999%.
2. The voltage level of the DC supply shall nominally be -48 V.
3. The combined rated current supplied by both the battery charger and battery bank shall be adequate to suit the foreseeable load within the design life, including a 15% allowance for degradation over its life.

4.2.0.2 Batteries

1. The minimum battery reserve period for the projected load must be set for 15 hr plus travel time from the MSP depot.
2. For distant, remote and difficult to access sites, the minimum battery reserve must be extended beyond the nominal reserve period.

4.2.0.3 Battery chargers

1. The DC supplies may be powered by a 230 V AC single phase supply or a 48 V solar PV supply.
2. Charger supply must be provisioned to allow automatic changeover to a temporary generator connected via pre provisioned 3 pin socket(s).
3. Earthing, the DC supply must have the positive side earthed creating a -48 V supply.

4.2.3 Constructability requirements

1. The Standards Australia compiled (in conjunction with Communications Australia, the ACMA and various telecommunications industry groups) CCM must be applied for all OT network installation work.
    a. AS/NZ 11801.1
    b. AS 11801.2
    c. AS/CA S008
    d. AS/CA S009
    e. AS/NZS ISO/IEC 24702
    f. HB 243
    g. HB 29

h. HB 252

2. All OT cabling work must be performed by an ACMA registered or licensed Telecommunications cabler in accordance with the Telecommunications Cabling Provider Rules 2014, Telecommunications Act 1997.
3. All telecommunications cabling work must be installed in accordance with AS/CA S009.
4. The materials used for telecommunications cabling installations must comply with AS/CA S008.
5. The Contractor must implement SiD activities in accordance with ElectraNet's SiD Procedure. The Contractor's work method statements must consider the safety features described in the SiD Report and the hazards identified on the FLHIA form(s).
6. Telecommunications work practices and requirements (particularly for external works) within the substation precinct must comply with and meet the substation environment's work requirements.
7. All ElectraNet OT equipment should mount onto 19" racking fitted to ElectraNet OT cubicles. If equipment does not have 19 in rack mounting capabilities, then the equipment must be securely affixed onto 19 in shelves that mount onto the 19" racking system.
8. All cabling must be securely constrained and groomed with methods appropriate to the type of cabling, with particular attention paid to the handling, securing, and grooming of optical fibre C.
9. Separate dedicated cable runways, meeting Telecommunications industry standards, must be installed and utilised for supporting Telecommunications optical fibre patch cords. Telecommunications optical fibre patch cords must be routed separately and independently from other general-purpose cables and their runways (e.g., telecommunications signal copper cables).
10. Pursuant to Telecommunications industry standards, cable-ties must not be used to cinch optical fibre patch cords. Optical fibre patch cords must be restrained with hook and loop straps and must be supported by dedicated support structures, not cinched to copper cabling for support.
11. Cable runways supporting power cables must conform to AS/NZS 3000. Consideration must be made to the requirement to separate power cabling from telecommunication signal cabling.
12. All ElectraNet OT equipment must be installed in a manner that protects the equipment against vermin attack, resists vermin attack and limits the potential damage that may be caused by vermin attack.

4.2.4 Maintainability requirements

1. To facilitate equipment accessibility, all ElectraNet OT cubicles must be laid out and installed such that there is a minimum 800 mm clearance or aisleway in the immediate vicinity of the cubicle's accessible faces.
2. Subrack (or chassis) based, modular equipment should be used where practicable. Fixed configuration, non-modular equipment may be used if deemed to be more suitable and/or cost effective (e.g., at smaller or edge sites).
3. For modular or subrack-based equipment:
   a. The expected lifecycle of the subrack should be (at least) double the expected lifecycle of the attendant modules/cards.
   b. The subracks should be compatible with future modules/cards, considering the equipment's future roadmap within a 10 year timeframe.
   c. The subracks should be selected based on suitability of backplane to cater for future requirements.

4. All modular equipment should have hot-swappable components, in particular power units, fan units (if used) and supervisory/control cards.
5. All ElectraNet OT equipment should utilise passive/convection cooling. If this is not possible, equipment should utilise hot swappable cooling components. The status of the cooling components must be alarmed.
6. All equipment labels must be placed so that are readily accessible and be able to be easily read whilst the equipment is in its operational position.

4.2.4.1 Point-to-point radio systems

1. All ElectraNet microwave radio systems must be indoor/outdoor split systems. Fully indoor microwave radio systems must be avoided.
2. All ElectraNet radio link terminals (RF transmitters) must have an attendant ACMA compliant transmitter Information label that identifies the ACMA licence details and the Licensee (the radio owner).

4.2.4.2 DC power supply -48 V DC

To facilitate the removal and installation of the heavy batteries, all ElectraNet -48 V DC power cubicles and attendant battery stillages should have 1200 mm clearance or aisleway (minimum of 900 mm) in the immediate vicinity of the power cubicle's accessible faces.

4.2.5 Maintenance spares

1. ElectraNet policy requires a minimum of 2 or 10%, whichever is the greater, of each equipment type/component to be held as spares. The holding of adequate levels of spares, to allow rapid replacement of faulty equipment, is an essential aspect of ElectraNet's maintenance policy.
2. Equipment options must be selected to leverage off the existing spares holdings (e.g., flange type selection for RF equipment must correlate with existing flange types).
3. For double-ended bearer equipment (e.g., radio link and PLC systems), maintenance spares holdings must be in the form of complete terminal ends. Maintenance spares terminal ends must contain one of every kind of card or unit which is in use in the field.
4. The Designer must consult with ElectraNet to determine what existing spares holdings there are for the proposed equipment and then determine if additional maintenance spares units are required to be provided by the project.

4.2.6 Operability requirements

1. All OT equipment must have integrated security features based on open standards and industry best practices.
2. Equipment must provide hardwired major and minor alarms that must be monitored by the on-site Alarm Monitoring equipment.
3. Equipment must be able to be remotely monitored, supervised, and managed by existing element and network management systems.
4. The equipment configuration and setting must be recorded in the ETCDB.
5. Equipment physical connections and interfaces (including expansion options) should utilise non-proprietary connectors/interfaces. Any proprietary connectors/interfaces should be clearly identified.
6. Equipment must be type tested for integration with the OT WAN systems.

7. Successfully type tested equipment must be added to 519 STD/0N1-001.
8. All equipment copper interface ports must be cabled out and terminated onto Krone termination frames using 10 pair Krone modules. The only exception is Ethernet ports which must be cable directly with Cat 5 Ethernet patch cords.

4.2.7 Performance requirements

1. The overall ElectraNet OT system (bearers and equipment) and its operations and management systems must have an averaged availability exceeding 99.99%.
2. The services must meet the general performance requirements outlined in:
   a. Table 1: Regulatory data service
   b. Table 2: Operational data services
   c. Table 3: Other data services
3. All services must meet the minimum performance requirements as stipulated in IEEE Std 1646.

4.2.7.1 Point-to-point radio systems

Individual microwave radio links in the ElectraNet OT Network must be designed to achieve at least 99.999% availability (315 s/year unavailability) at a receiver threshold criterion associated with a BER of $1x10^{-6}$.

4.2.8 Testing and validation requirements

1. ITPs must be prepared to record procedure to be undertaken to perform a defined work activity and to record evidence (including test results) that the equipment used, and the work activity performed, meets, or exceeds the specified requirements.
2. For unique and complex equipment and system scenarios, FAT must be performed at the manufacturing facility/equipment supplier, where the equipment is commissioned in accordance with the final network/system design. Upon successful completion of the FAT, the equipment/system must be disassembled, transported to site, and installed/reassembled in its final operational locality, where SAT and on-site commissioning must be performed.
3. Equipment and systems that pass all testing and commissioning regimes must be offered for integration and acceptance into the OT network.

4.2.8.1 Point-to-point radio systems

1. The availability of a point-to-point radio link must be tested and proven over a 30-day soak period during the radio link's commissioning phase.
2. During a 30-day test period the RF (combined) link receive level (in both directions) must exceed the defined (BER $10e^{-6}$) receiver sensitivity threshold for 99.999% of the test period.
3. The measured RF receive levels (in both directions) at Main and Diversity antennae are within +/-3 dB of predicted level.
4. Validate the RF flat fade margin (in both directions) by measuring the receive channel noise level (radio transmit off). The intent is to confirm no interfering signal within the receive channel. The measured noise level must be more than 30 dB below the receiver sensitivity threshold.

Table 4: Point-to-point radio systems, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
RF path	Better than defined Rx Sensitivity @ BER $10e^{-6}$	30 d
Radio receive RF level	Within +/-3 dB of predicted	1 min
Radio receive noise level	Better than 30dB below Rx Sensitivity @ BER $10e^{-6}$	1 min

4.2.8.2 Optical fibre cable

1. Optical fibre cable testing must be carried out using a LSPM and an OTDR. Testing of the 'permanent link' must conform to AS/NZS ISO/IEC 14763.3 using the 3-jumper method.
2. The measured optical attenuation in both directions is within +/-1dB of predicted level at 850 nm wavelength (for multimode) and 1310 nm, 1550 nm, and 1625 nm wavelengths (for single mode) using LSPM.
3. The measured end to end optical fibre length is within 1% of predicted length using OTDR.
4. No detected anomalies along length of optical fibre cable using OTDR.
5. Provide visual cable trace/signature with associated viewing software.

Table 5: Optical Fibre Cable, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
Optical attenuation	Within +/-1 dB of predicted	LSPM using 3-jumper method
Cable length	Within 1% of predicted	OTDR using launch and tail cords
Cable continuity	No anomalies	OTDR using launch and tail cords

4.2.8.3 Power line carrier

1. The measured HF receive level is within +/-3 dB of expected level.
2. The measured SNR is better than 30 dB.

Table 6: Power line carrier, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
PLC receive HF level	Within +/-3 dB of expected	1 m
PLC SNR	Better than 30 dB	1 m

4.2.8.4 PDH digital path

The PDH digital path must meet performance objectives as specified in ITU-T M.2100. The recommendation M.2100 is intended to assure the requirements of ITU-T G.821 and ITU-T G.826 (long-term performance) are met, but allows for shorter test periods e.g., 2 days. The aim is also to facilitate 'in-service' performance assessment, making use of error monitoring equipment included in the actual communication systems. The BISO is an important parameter in M.2100 and is chosen to

be a fraction of the ITU-T G.821 and ITU-T G.826 limits. To determine the BISO applicable for ElectraNet network paths the path allowance must be defined as 2% (path length <500 km).

Thus, for an E1 (Primary Rate) link over a 2 day test period the BISO is computed as:

$$BISO = 0.02 * 2\% * 2d * \frac{(26 * 60 * 60)}{2}$$

Table 7: PDH digital path, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
M.2100 E1 Primary rate	34ES (2% path allowance)	2 d

4.2.8.5 SDH digital path

To maintain a consistent approach the M.2100 performance objectives are also applied to SDH digital paths.

Thus, for an STM-1 (Quaternary) link over a 2 day test period the BISO is computed as:

$$BISO = 0.08 * 2\% * 2d * \frac{(26 * 60 * 60)}{2}$$
$$= 172\ errored\ seconds$$

Table 8: SDH digital path, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
M.2100 STM-1 Quaternary rate	172ES (2% path allowance)	2 d

4.2.8.6 IP network path

1. The packet switched network path must use Ethernet framing.
2. The Ethernet path test must be based on ITU-T Y.1564 based on 99.999%

Table 9: Packet switched network path, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
Bandwidth	27 Mbps CIR	2 d
Frame transfer delay	5 ms @ 1580 L2 MTU	2 d
Frame delay variations	0.1 ms	2 d
Frame loss ratio	1:10000	2 d
Availability	99.999%	2 d

4.2.8.7 E1 service

1. To maintain a consistent approach the M.2100 performance objectives are applied to E1 (Primary Rate) service paths.
2. Thus, for E1 service paths over a 10 min test period the BISO is computed as:

$$BISO = 0.02 * 2\% * 10\ min * \frac{60}{2}$$
$$= 0\ errored\ seconds$$

Table 10: E1, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
M.2100 E1 Primary rate	0ES (2% path allowance)	10 min

4.2.8.8 C37.94 (G.703 64k) service

To maintain a consistent approach the ITU-T M.2100 performance objectives (based on ITU-T G.821) are applied to sub-primary service paths.

Thus, for 64 k service paths over a 10 min test period the BISO is computed as:

$$BISO = 0.04 * 2\% * 10\ min * 60$$
$$= 0\ bit\ errors$$

Table 11: C37.94 (G.703 64k), performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
M.2100 64 k Sub-primary rate	0 errors (2% path allowance)	10 min

4.2.8.9 Ethernet service

1. The Ethernet service test must be based on RFC 2544.
2. Throughput is the maximum amount of data that can be transported without frame loss and should be better than 50% of the bandwidth allocated.
3. Latency is the round-trip delay for a frame to traverse the loopback. It should not vary by more than 10%.

Table 12: Ethernet, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
Throughput (Mbit/s)	>50% of bandwidth	2 min
Latency	<10% variation	2 min

4.2.8.10 Telephone service

The Telephone service test is a functional test for both the OPAX and PSTN services.

1. Outgoing call
2. Off-hook- receive dial tone
3. Dial external (mobile) number – receive ring tone
4. Connect to B party- confirm number dialled
5. Incoming call
6. Request call – receive ringer phone and LSA
7. Off-hook – ringer stops

- Connect to A party – confirm number dialled

Table 13: Telephone, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
Outgoing telephone call	Dial tone	-
	Ring tone	-
	Connect to B party	1 min
Incoming telephone call	Bell ring and LSA	-
	Connect to A party	1 min

4.2.8.11 DC power supply -48 V DC

1. The following functional test must confirm the operation of each -48 V DC power supply including rectifier and battery function.
2. Measure maximum charging current which must equal the design charging current.
3. Verify alarms activate (and extend to ElectraNet network management system) including AC fail and battery volts low/high.
4. Conduct 20 min short term discharge on battery string using (nominal) 2 kW load. Record battery and cell voltages at 2 min intervals. Battery voltage remains greater than -48.0 V. This is intended to confirm the function of the battery and connections.

Table 14: DC Power Supply, performance, acceptance, and testing

Performance metric	Acceptance criteria	Test period
Maximum charging current	Equals design value	1 min
Alarms	AC Fail, Battery Volts Low/High	-
Battery discharge test	Battery Volts > -48 V	20 min

4.2.9 Asset information requirements

1. All OT assets must be identified in SAP and must be provided with a unique FunLoc and barcode.
2. All OT assets must be planned, designed, and managed (e.g., configuration, settings, etc.) in ETCDB.
3. All on-site equipment must be clearly labelled with the equipment's ETCDB asset name and the asset barcode. For exterior equipment, the self-adhesive asset barcodes and referencing the equipment's ETCDB asset identification must be placed on an external asset barcode plate that must reside in an accessible location within the associated Telecommunications equipment room.
4. Environmentally exposed labels must be permanent external grade labels that offer very high UV resistance.
5. Underground cable sheaths (and other underground equipment) must be identified and labelled in all access pits with permanent external grade labels capable of withstanding immersion in standing water.

6. All equipment must be provided with attendant dedicated operational firmware/software (e.g., system licenses, management information base, network management system interfaces, local craft terminal application, remote access application, warranty information, factory inspection test results, commissioning test records and any other documentation (installation, operations, and maintenance) pertinent to the equipment provided.

City West Substation

Appendices

ElectraNet

Appendix A Generic OT deployment

Figure 1: Generic OT deployment at substation

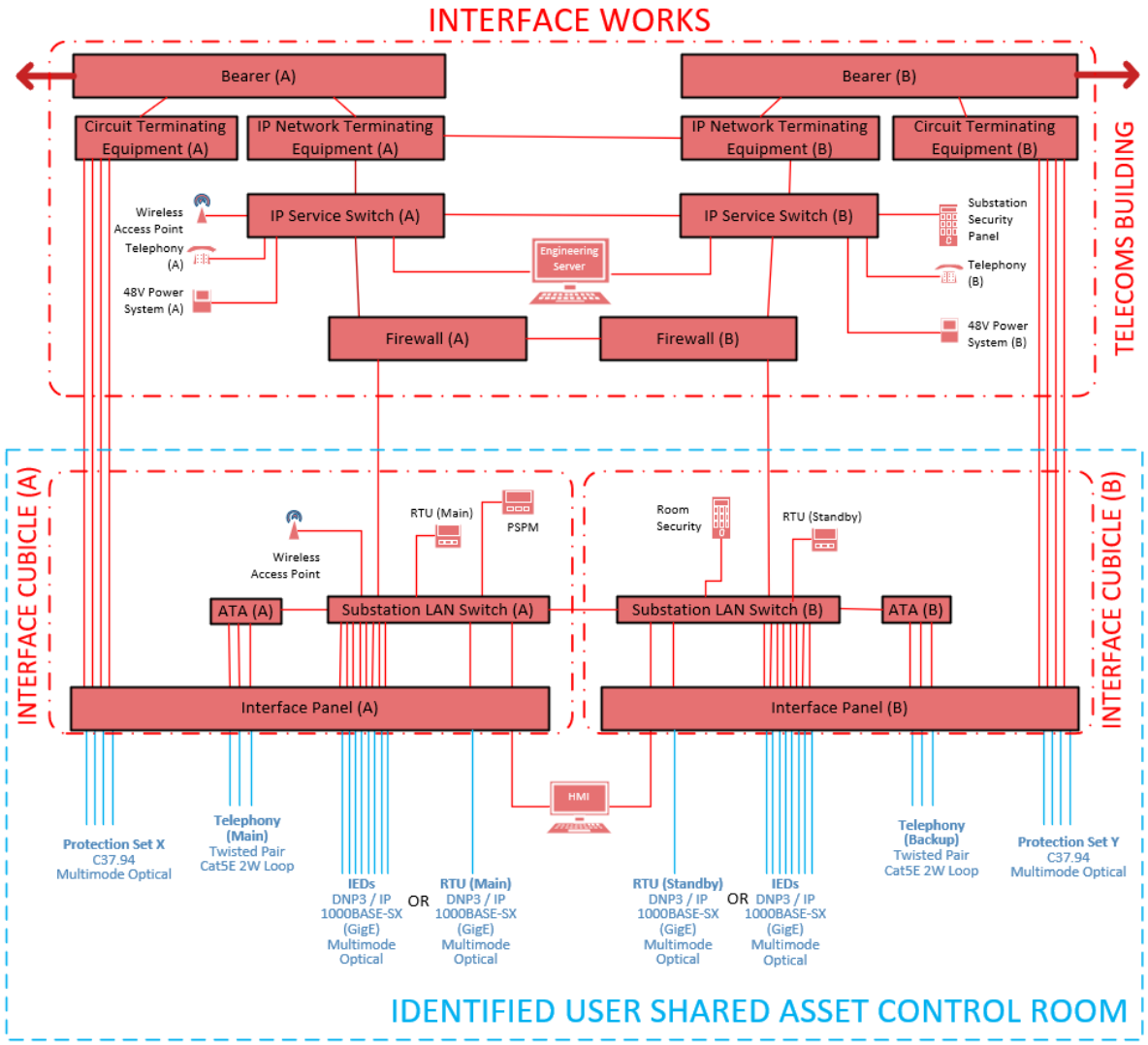


Figure 2: Generic OT deployment at an IUSA interface

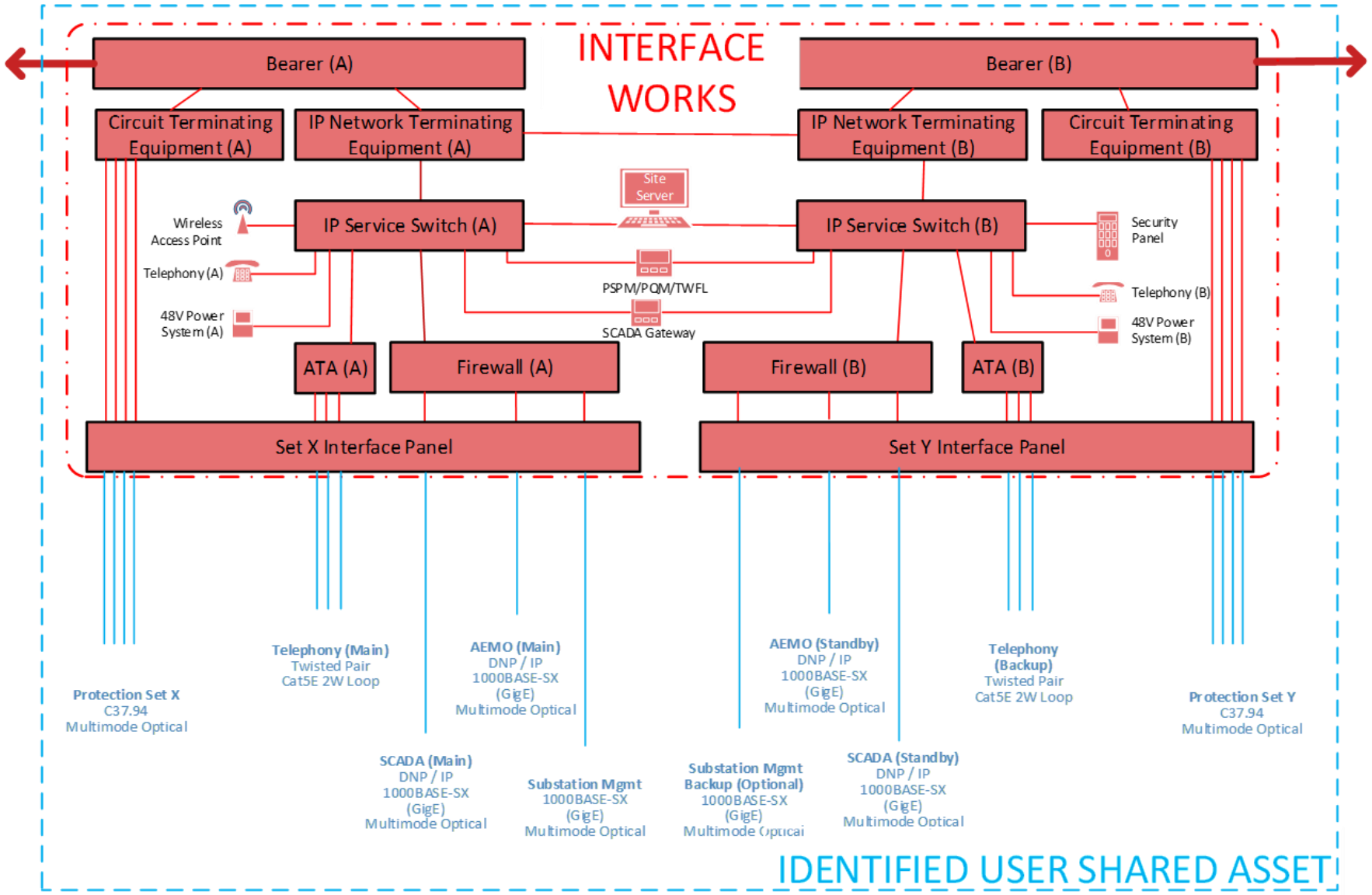
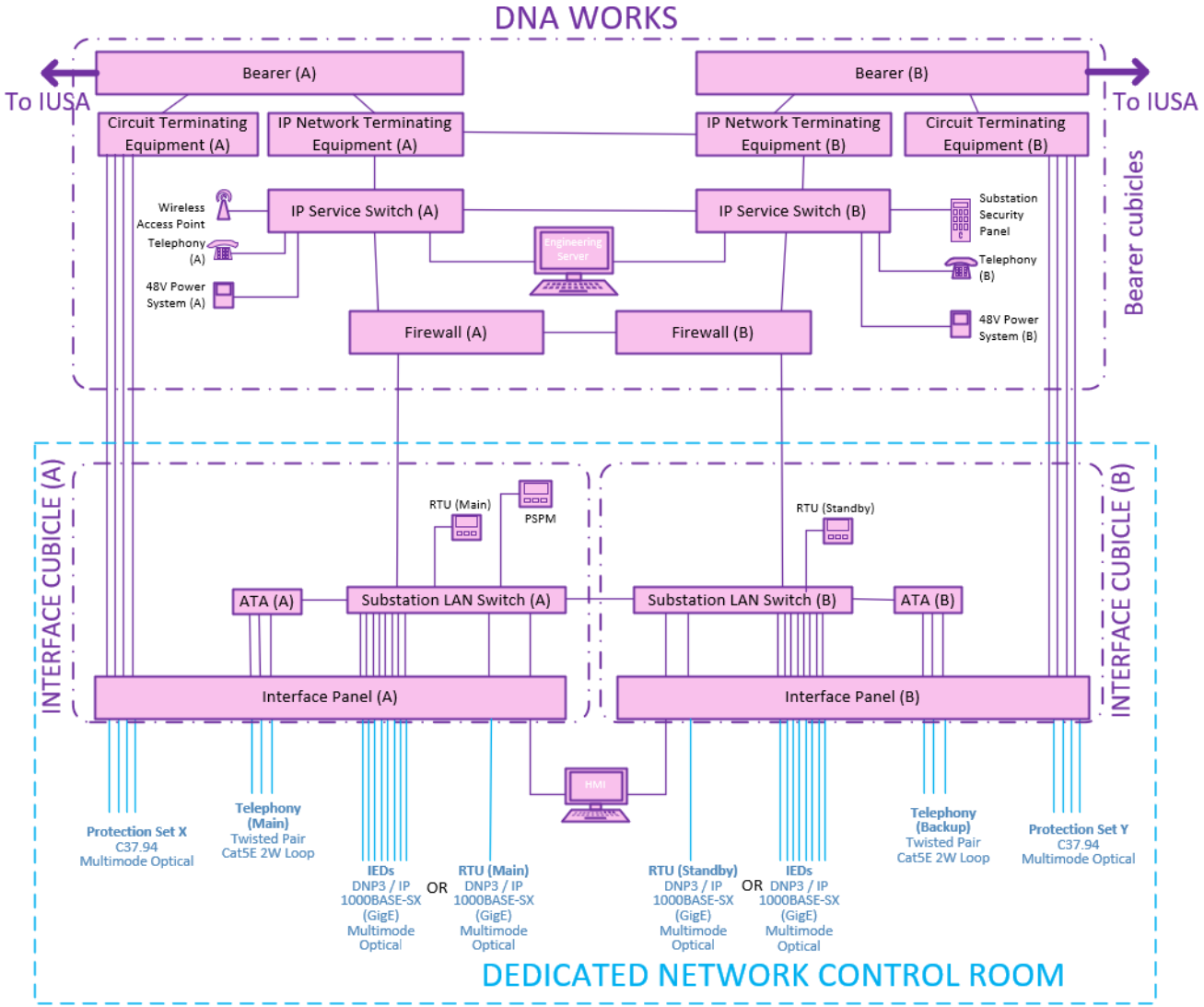


Figure 3: Generic OT deployment at DNA substations



References

Organisations

Organisation	Description	Details
ACMA	Commonwealth Government Statutory Authority	AUSTRALIAN COMMUNICATIONS AND MEDIA AUTHORITY ABN 55 386 169 386
AEMC	State Government Statutory Authority	AUSTRALIAN ENERGY MARKET COMMISSION ABN 49 236 270 144
AEMO	Australian Public Company *Note: Before its change of name, AEMO was known as NEMMCO.*	AUSTRALIAN ENERGY MARKET OPERATOR LIMITED, ABN 94 072 010 327
AER is constituent part of the Australian Competition and Consumer Commission (ACCC)	Commonwealth Government Entity	AUSTRALIAN COMPETITION & CONSUMER COMMISSION ABN 94 410 483 623
Telstra	Australian Public Company	TELSTRA CORPORATION LIMITED ABN 33 051 775 556

Legislation

Legislation	
NER	National Electricity Rules
Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2014, Radiocommunications Act 1992	
Telecommunications Cabling Provider Rules 2014, Telecommunications Act 1997	

Standards

Name	Title
AS 11801.2	Information technology - Generic cabling for customer premises, Office premises
AS/CA S008	Requirements for customer cabling products
AS/CA S009	Installation requirements for customer cabling (Wiring Rules)
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 11801.1	Information technology - Generic cabling for customer premises, General requirements
AS/NZS IEC 60825.2	Safety of laser products
AS/NZS ISO/IEC 14763.3	Telecommunications installations - Implementation and operation of customer premises cabling, Testing of optical fibre cabling

Name	Title
AS/NZS ISO/IEC 24702	Telecommunications installations - Generic cabling - Industrial premises
EN 300 462 (series)	Transmission and multiplexing (TM); Generic requirements for synchronization networks
ETS 300 147	Transmission and multiplexing (TM); synchronous digital hierarchy (SDH) - multiplexing structure
ETSI ETR 241	Transmission and Multiplexing (TM); Functional architecture of 2 Mbit/s based Plesiochronous Digital Hierarchy (PDH) transport networks
HB 29	Communications cabling manual - Module 2: Communications cabling handbook
HB 243	Communications Cabling Manual - Module 1: Australian regulatory arrangements
HB 252	Communications Cabling Manual - Module 3: Residential communications cabling handbook
IEC 61850 (series)	Communication networks and systems for power utility automation
IEEE Std 1613.1	IEEE Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations
IEEE Std 1646	IEEE Standard Communication Delivery Time Performance Requirements for Electric Power Substation Automation
ISO/IEC 11573	Information technology Telecommunications and information exchange between systems Synchronization methods and technical requirements for Private Integrated Services Networks
ISO/IEC 11801	Information technology Generic cabling for customer premises
ITU-T G.652	Characteristics of a single-mode optical fibre and cable
ITU-T G.702	Digital hierarchy bit rates
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces
ITU-T G.704	Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels
ITU-T G.707	Network node interface for the synchronous digital hierarchy (SDH)
ITU-T G.711	Wideband embedded extension for ITU-T G.711 pulse code modulation
ITU-T G.723	Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s
ITU-T G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
ITU-T G.811	Timing characteristics of enhanced primary reference clocks
ITU-T G.821	Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an Integrated Services Digital Network
ITU-T G.822	Controlled slip rate objectives on an international digital connection
ITU-T G.826	End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections
ITU-T G.957	Optical interfaces for equipments and systems relating to the synchronous digital hierarchy

Name	Title
ITU-T M.2100	Performance limits for bringing-into-service and maintenance of international multi-operator PDH paths and connections
ITU-T Y.1564	Ethernet service activation test methodology
RALI FX3	Microwave fixed services *Informative: This is a standard published by ACMA.*
RFC 2544	Benchmarking Methodology for Network Interconnect Devices *Informative: This is a standard published by IETF.*
-	Power System Data Communication Standard *Informative: This is a standard published by AEMO.*

ElectraNet documents

Name	Title
1-02-OP28	New Equipment Evaluation and Approval Policy
1-09-FR-01	Protection Common Functional Requirement
1-09-FR-25	DC Supply System
1-07-M06	Transmission Asset Access Manual, Rules and Procedures
1-16-OP01-P013	Safety in Design Procedure
1-16-OP01-P014	Plant Lifecycle Hazard Management Procedure for New and Modified Installations

ElectraNet drawings

Name	Title	Subtitle
519 STD/0N1-001	TELECOMMUNICATIONS EQUIPMENT	TELECOMMUNICATIONS EQUIPMENT LIST (TEL)

ElectraNet