Communication Systems

AMS – Electricity Distribution Network

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1 Executive Summary

The AusNet Services electricity distribution network covers over 80,000km^2 in eastern Victoria and serves more than 600,000 customers. There are 99 locations (15 radio sites, 69 zone substations and 15 terminal stations) with distribution communications assets. The electrical distribution network employs communications systems primarily for the following applications:

- Protection Signalling – Between zone substations and terminal stations and in-between zone substations
- Monitoring and Control (SCADA) – Between the Network Operations Centre (CEOT) and zone substations and pole mounted medium voltage switches
- Operational Voice Communications – Between CEOT, offices, depots, terminal stations and zone substations
- Operational Data Communication – Supporting asset data collection, engineering access, site surveillance and access control.

The distribution communications network has grown significantly over the last 12 years as part of communications network expansion program into distribution sites. It is expected the communications network will continue to grow in the next five years due to electricity network modernisation and augmentation. Radio Communication Links and Fibre Links are in relatively healthy condition, whereas major asset replacement is required in legacy systems like Plesiochronous Digital Hierarchy (PDH) and Synchronous Digital Hierarchy (SDH).

The condition and suitability for purpose of Communication assets have been evaluated based on their current performance, historical failure events and vendor supportability with spare parts and ongoing technical advice. Lack of vendor support and shortage of spare parts for legacy systems has played an important role in deciding the probability of failure and risk to business continuity.

Legacy systems approaching end-of-life with diminishing vendor support and spare parts has been given priority in the procurement process to either secure adequate spare parts to extend the usable life or replace as a last resort. In situations where the entire fleet is reaching end-of-life, a staged replacement strategy has been adopted to reuse decommissioned assets as spare parts to extend the life of the remaining asset fleet.

This Asset Management Strategy (AMS) outlines various communications related technologies, their condition and strategies aimed at enhancing the reliability of distribution network and Information and Communications Technology (ICT) systems to efficiently deliver existing and future communication services.

The Metering network related Communication Technologies, asset conditions and related initiatives are excluded from this AMS document and can be found in AMS 21 – 04 Electricity Distribution Metering – Telecommunications Infrastructure.

Following areas of the Communication Network require attention over the next five to ten years.

- Replacement of SDH and PDH equipment
- Replacement of TRIO remotes
- Establishment of a Transition programme from 3G to 4G/LTE
- Replacement of DIC Switches and Serial Servers
- Extending the OTN network to zone substations
- Continue implementation and Integration of SEIM Visibility
- Continue implementation of centralised authentication, authorisation and audit control

2 Introduction

2.1 Purpose

This document forms part of the Asset Management System for compliance with relevant standards and regulatory requirements. The document demonstrates responsible asset management practices by outlining economically justified outcomes for the Communication systems in the AusNet Services Electricity Distribution Network.

This document is intended to inform asset management decisions and communicate the basis for activities.

2.2 Scope

The following communication systems are included in this document:

- Communications Bearers (Optic Fibre cables and Point-to-Point radio systems)
- Wireline Technologies (Circuit switched and Packet switched equipment)
- Wireless Technologies (3G and Point-to-Multipoint radio equipment (TRIO))
- Telephony Technologies (Operational Telephony Systems, Trunk Mobile Radio (TMR))
- Supporting Infrastructure (Antennas)
- Operational Support Systems (Network Management Systems (NMS) and Element Management Systems (EMS))

The following assets are covered in other AMS documents

- Buildings and air conditioners AMS 20-55
- Power supplies (Batteries, chargers) AMS 20-80
- Communication towers AMS 20-64
- Business Telephone Systems, Public Carrier and Other Telephony (ICT Submission)

2.3 Asset Management Objectives

As stated in *AMS 01-01 Asset Management System Overview*, the high-level asset management objectives are:

- Comply with legal and contractual obligations;
- Maintain safety;
- Be future ready;
- Maintain network performance at the lowest sustainable cost; and
- Meet customer needs.

As stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*, the electricity distribution network objectives are:

- Improve efficiency of network investments
- Maintain long-term network reliability
- Implement REFCLs within prescribed timeframes
- Reduce risks in highest bushfire risk areas
- Achieve top quartile operational efficiency
- Prepare for changing network usage

3 Asset Description

3.1 Asset Function

The AusNet Services communications network enables the transfer of information between various electricity network operating systems, applications and devices. The network provides services for power system protection, SCADA (Supervisory Control and Data Acquisition), asset data gathering, business computer applications, telephony systems, remote engineering access, and Smart grid applications.

Communication systems enable protection devices to constantly exchange information and in the event of a fault the appropriate protection devices operate to de-energise the faulted equipment and minimise the risk of injury or damage of other equipment.

Field devices including remote terminal units (RTUs), control boxes, and smart meters use the communication systems to send electricity network data to the CEOT through the SCADA master or other master server and to receive instructions from the CEOT or SCADA master to reconfigure the electricity network.

The telephony systems assist the CEOT to interact with the field operations teams when providing instructions in case of faults or planned network maintenance work.

Through communication systems, engineers and field teams are able to remotely access field devices and diagnose network failures or get access to drawings and other databases that are used to maintain the network and avoid multiple journey to depots and offices.

The range of applications supported by communication services are enabled through various telecommunications technologies as shown in the overview Figure 1.

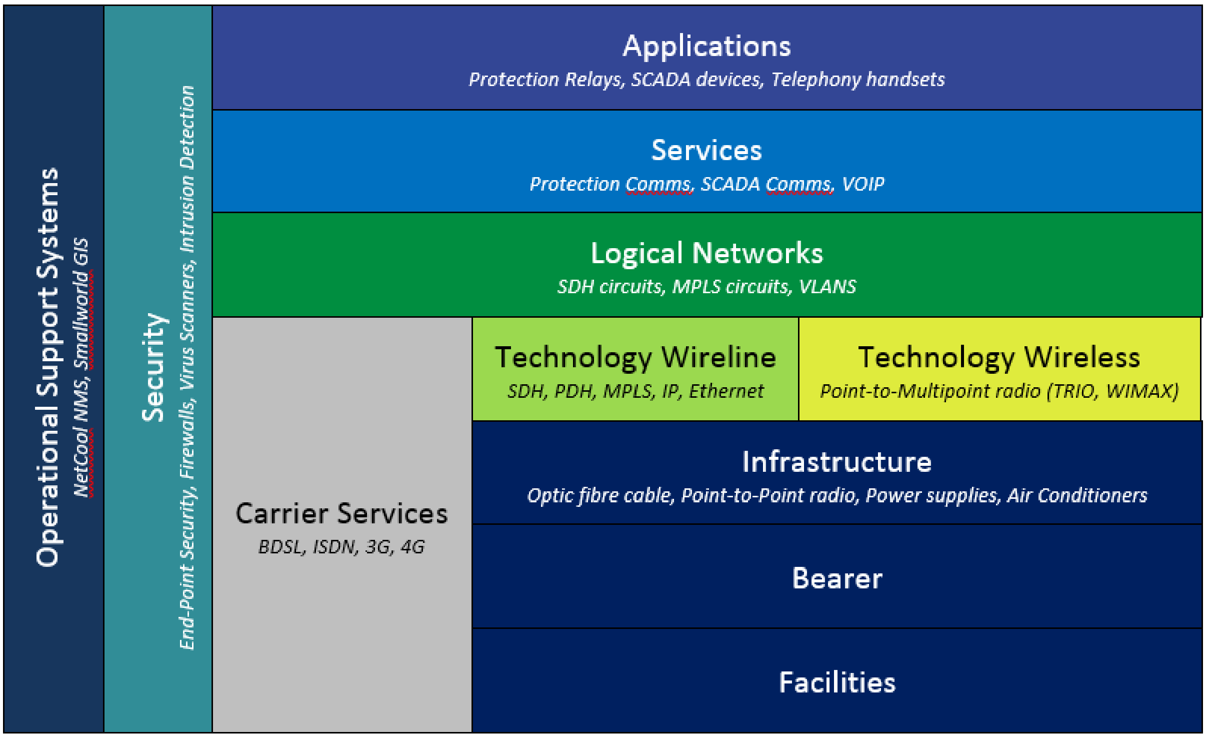

Figure 1: Overview of the AusNet Services Communications Segments

The functions of the systems can be grouped into the following categories; communications bearers, wireline technologies, wireless technology, telephony technologies, supporting infrastructure, operational support systems, and security systems and services

The function capabilities are measured by to four main “quality” factors; end-to-end performance, reliability/availability, bandwidth, and Security.

Figure 2: Measures for Communications System functions

3.1.1 Communications Bearers

Communication bearers provide the interconnectivity medium from one physical location to another. The bearers used in AusNet Services include optical fibre cables and point-to-point microwave radio. Where optical fibre and radio is not economic, 3rd party services such as Asymmetric Digital Subscriber Line (ADSL), Broadband Digital Subscriber Line (BDSL), and Integrated Services Digital Network (ISDN) are used as bearer links.

Optical Fibre bearers are very reliable, provide the greatest data throughput per dollar and has a long life expectancy. Where Optical Fibre is not economic and the terrain can support line-of-sight media, point-to-point microwave radio links are deployed as bearer links.

3.1.2 Wireline Technologies

Wireline technologies enable communications services and applications to access the communications bearers. There are four types of Wireline networks classified as:

- Operational Data Network (ODN)
- Operational Management Network (OMN)
- Corporate Network
- AMI – multiprotocol label switching (MPLS) Network.

The Metering network and its associated assets form part of a separate Asset Management Strategy document and is excluded from this document.

3.1.2.1 Operational Data Network (ODN)

The ODN carries power system protection data for zone substations, SCADA, and Operational telephony traffic. The ODN is based on Time Division Multiplexing (TDM) technology and uses Plesiochronous Digital Hierarchy (PDH) as the access network, and Synchronous Digital Hierarchy (SDH) as its aggregation and transport network. Wavelength Division Multiplexing (WDM) equipment augments the transport network to either extend the geographical distance between the SDH nodes or address fibre capacity limitations.

3.1.2.2 Operational Management Network (OMN)

The OMN provides access for remote management of various power network devices and carries sensitive information about power network management settings. This network spans 44 locations and is based on packet switched technology consisting of switches and routers.

3.1.3 Wireless Technology

Wireless communication services enable end devices to access the communication network. The wireless platforms predominantly provide communications services to SCADA and remote engineering access. This service is currently provided by the AusNet Services owned TRIO network and third party 3G network.

The TRIO and 3G wireless networks provide telemetry and control for 2196 pole top devices and nine remote terminal units (RTUs) at zone substations.

3.1.4 Telephony Technologies

AusNet Services relies on telephony for voice communication between operational staff to operate and maintain the electricity network. The operational telephone system is a combination of AusNet Services owned systems and third party provided services. The third party networks include TMR and satellite handsets. In combination, the system provides highly reliable telephony capability to operational sites independent of public telephony systems.

The internal systems provide facilities to connect the CEOT to other controlling authorities and an interface to the public carrier networks. Satellite phones are used when other conventional methods are not available and the TMR system is used by field staff for voice communication in areas where the public telephone network is poor.

3.1.5 Supporting Infrastructure

Supporting infrastructure consists of assets that are auxiliary to communication systems, and do not actively carry or transport communications traffic themselves. These include; antennas, towers, site buildings, fencing, security systems, power supplies, and air conditioners.

This strategy document only covers antenna systems.

3.1.6 Operational Support Systems

Operational support systems are used as diagnostic and remote management software tools. These systems are vendor specific and may include element management systems for WDM, SDH, PDH and TRIO. An overarching software application (NETCool) is used to view the various element managers.

3.1.7 Security Systems and Services

Security systems and services protect the AusNet Services computer network from Cyber-attacks. An industrial embedded firewall from [C.I.C] is deployed to protect traffic across links that use public communications infrastructure such as 3G or 4G networks. Zone substations are secured by access control lists (ACL) and 802.1x on all on-site networking equipment

3.2 Asset Population and Age

The AusNet Services electricity distribution network has communication assets at approximately 2,332 geographical locations (zone substations, Control Centres, data centres, administrative offices and Pole top locations) as shown in Table 1.

Communication Asset Locations	**Sites**
Zone Substations	63
Radio Sites	20
Terminal Stations	15
Data Centres	2
Office/Depots	36
Pole Top Locations	2,196
Total Communication Sites	**2,332**

Table 1: Communication Asset Locations

The list of assets and the average age for each asset group is provided in the tables below

3.2.1 Communication bearers

Group	Type	Length/Quantity
Optical Fibre Cable	OPGW (1 route)	43km
	ADSS (160 routes)	620km
	Underground	15km
Point-to-Point Radios	TRIO	2
	Aprisa	12
	CERAGON	8

Table 2 Communication Bearers

3.2.2 Operational Data Network

System	Quantity
PDH	94
SDH	96
CWDM	8
DWDM	21
TELEPROTECTION	16

Table 3: Wireline Technologies - Operational Data Network Assets

3.2.3 Population

3.2.3.1 Operational Management Network

System	Make	Total Quantity
Routers	RUGGEDCOM RX 1500	16
	Cybertec 2100	8
	RUGGEDCOM RSG2100	34
	ASR 603	1
Switches	ASR 903	4
	CISCO 3550	1
	CISCO 3750	55
Serial Servers	RS416	62
	Dell R200	2

Table 4: Wireline Technologies - Operational Management Network Assets

3.2.3.2 Wireless Technology

System	Total Quantity
Base Stations	32
TRIO Modems on Pole Tops	182
TRIO Modems at ZSS	9
3G Modems	2014
TOTAL	

Table 5: Wireless Technology Assets

3.2.3.3 Telephony Technologies

System	Vendor	Quantity
PABX – BCS 150	ERICSSON	2
PABX IT CONSOLE SYSTEM	BT	1
PABX - HIPATH	SIEMENS	1
PABX – IPx OFFICE	TADIRAN	4
PABX – Ucx	TADIRAN	1
TMR units (car and portable)	PHILIPS/SIMCO/TAIT	245
TMR LDT	TAIT	12

Table 6: Telephony Assets

3.2.3.4 Supporting Infrastructure

Systems	Quantity
Antennae	38

Table 7: Supporting Infrastructure Assets

3.2.4 Age Profile

3.2.4.1 Optical Fibre

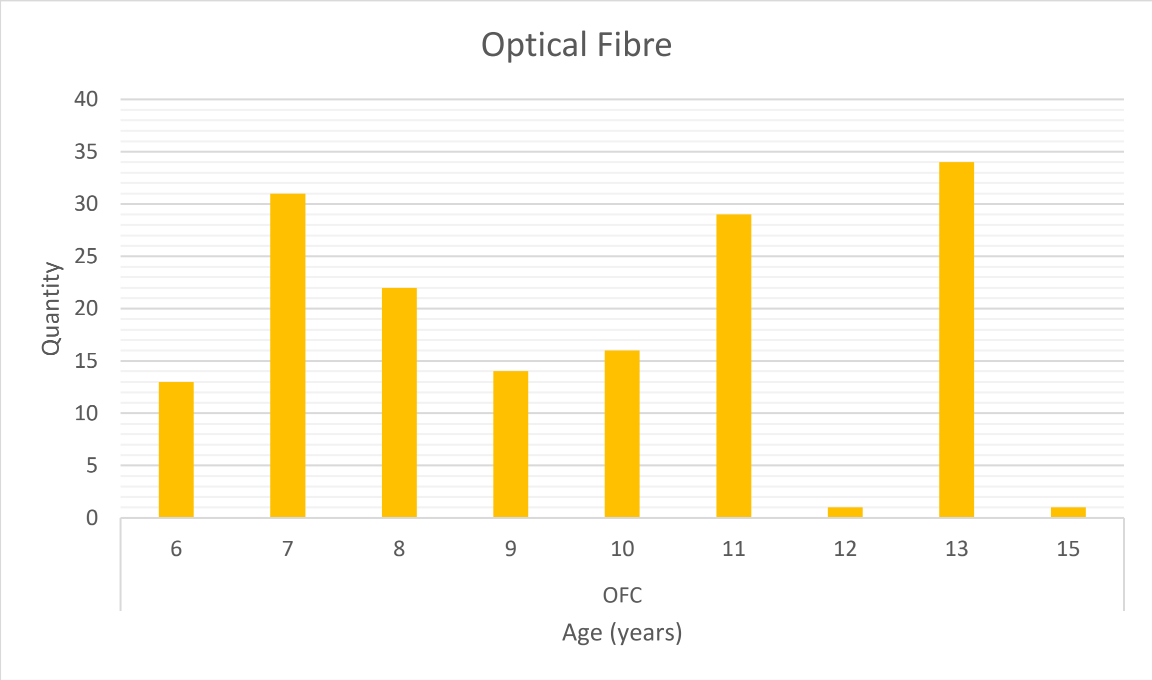

Figure 3 Age Profile - Optical Fibre

3.2.4.2 Radio Systems

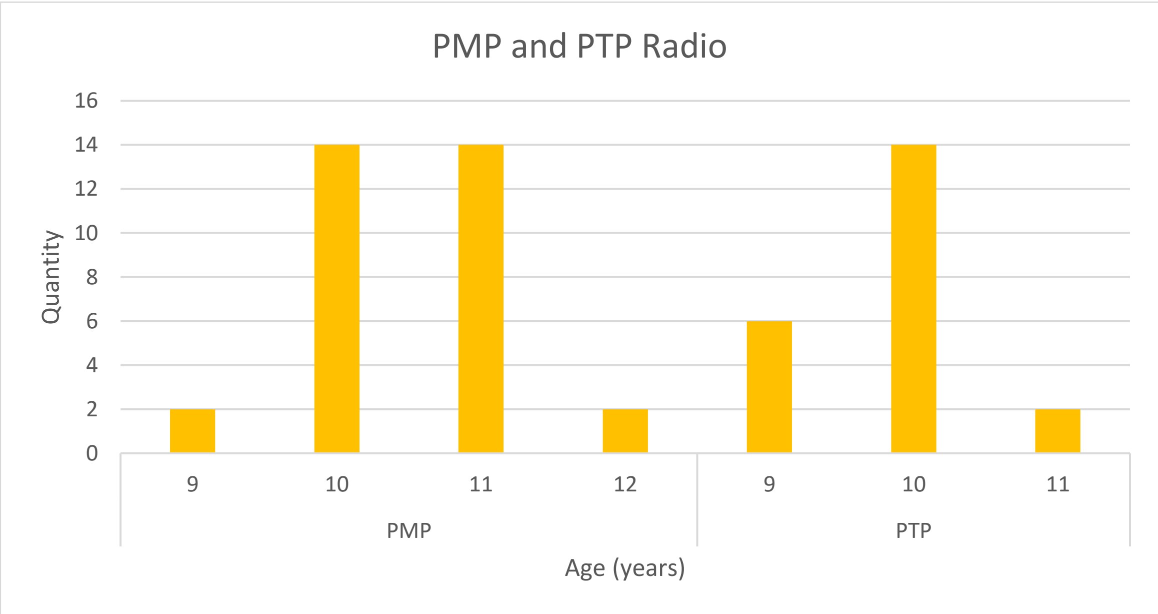

Figure 4 Age Profile - PMP and PTP Radio

3.2.4.3 PDH SDH WDM and TPS

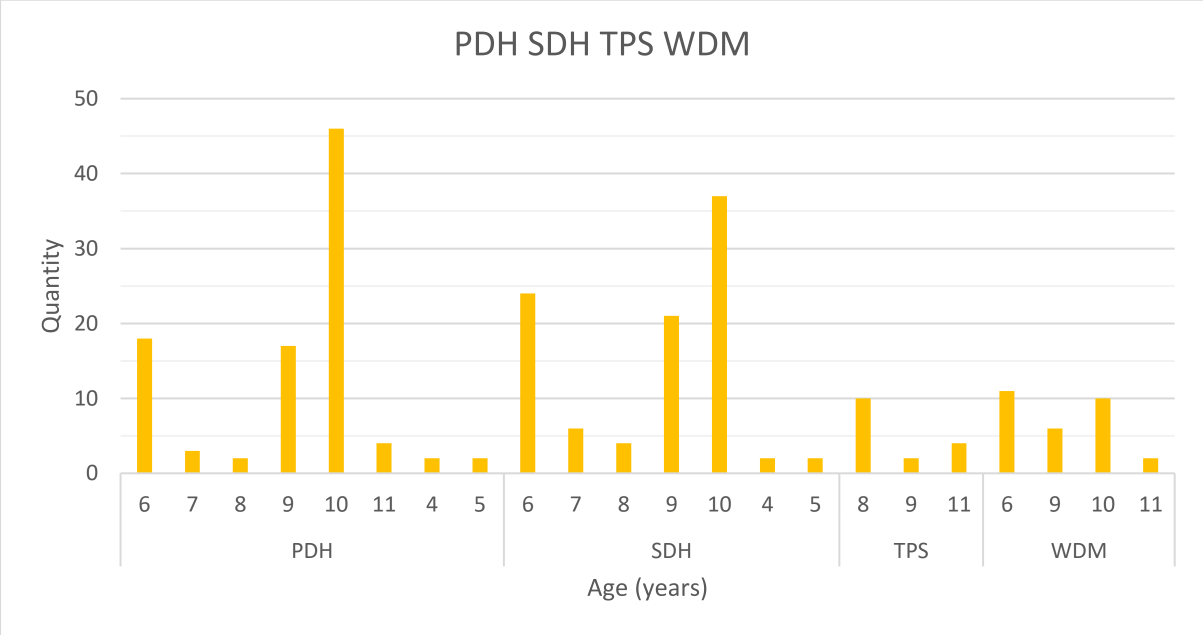

Figure 5 Age Profile - PDH SDH TPS and WDM

3.2.4.4 DIC Systems

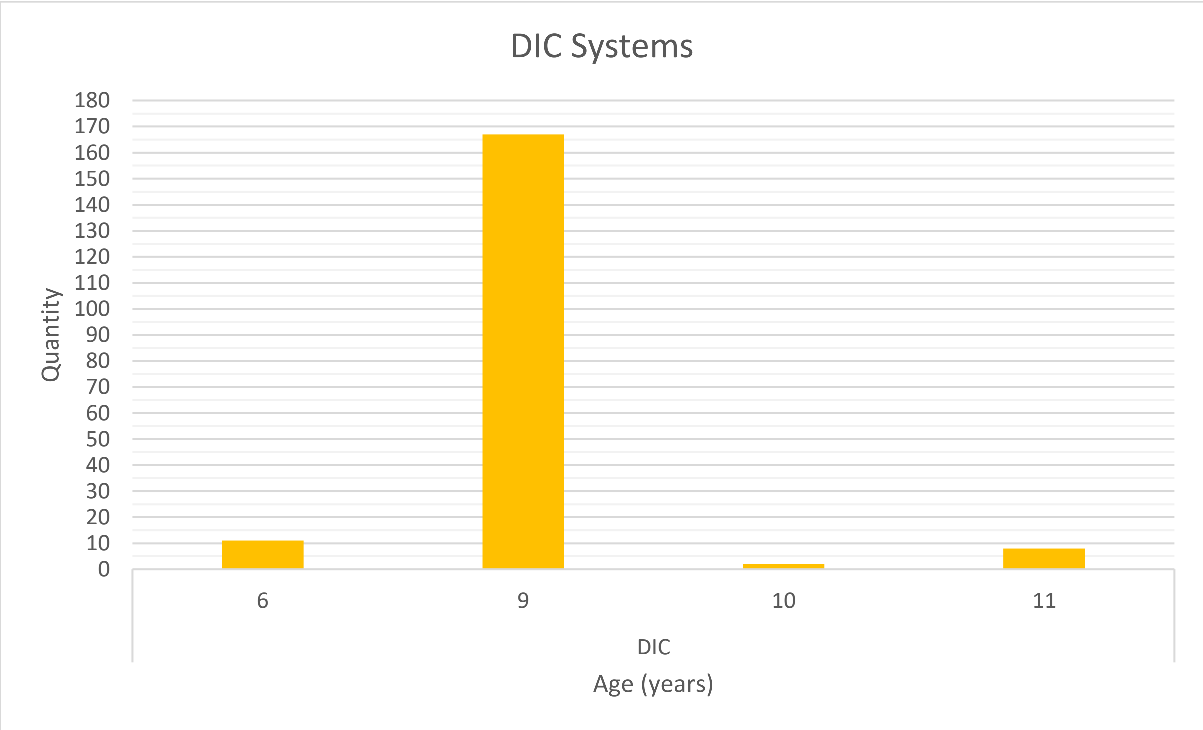

Figure 6 Age Profile - DIC Systems

3.2.4.5 Antenna Systems

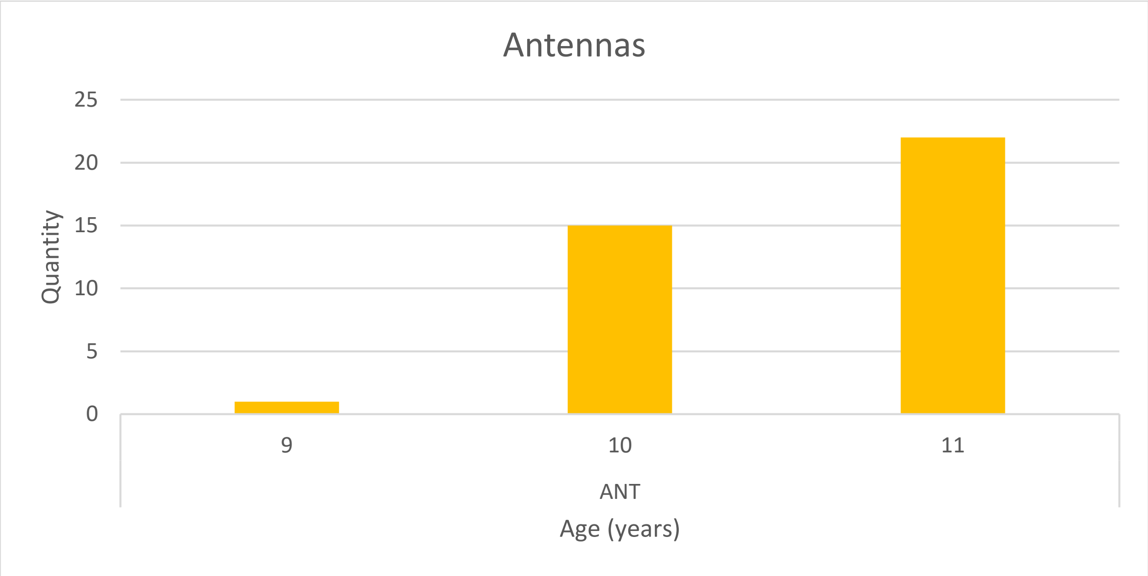

Figure 7 Age Profile - Antennas

3.3 Asset Condition

Asset condition is used as a measure of determining the remaining service potential of an asset at a given time. AusNet Services uses a 5-point scale for the condition scores (C1 to C5) to provide an indication of the remaining service potential of an asset - C1 is considered to be As-Good-As-New and C5 is considered to be end-of-life. The metrics and methodology of calculating the condition scores for communication assets is provided in the Communication Systems Asset Health Report. Table 8 below shows the relationship between the condition score, remaining service potential, and a description of the asset status.

Condition Score	Condition	Description	Remaining Service Potential
C1	Very Good	– Some aging or minor deterioration of a limited number of components – Normal maintenance	95%
C2	Good	– No trends of deterioration in condition or performance recorded – Normal maintenance	70%
C3	Average	– Asset showing signs of deterioration in performance – Manufacturer support is becoming limited – Asset typically requires increased maintenance and monitoring	45%
C4	Poor	– Serious deterioration of asset performance – Manufacturer support and spares is typically not available – Not compliant to industry or government standards and legislation within five years – Start planning process to replace considering risk and consequences of failure	25%
C5	Very Poor	– Extensive serious deterioration of asset performance – Manufacturer support not available – Depleted stocks of spares – Lack of experience and skills required to maintain asset – Not compliant to industry or government standards and legislation – Immediately assess risk and replace based on assessment	15%

Table 8: Description of Asset Condition Score

Figure 8 shows the condition of assets as determined in the Asset Health Report and some consideration of forecasted changes. The figure shows system type and number of systems at each condition score.

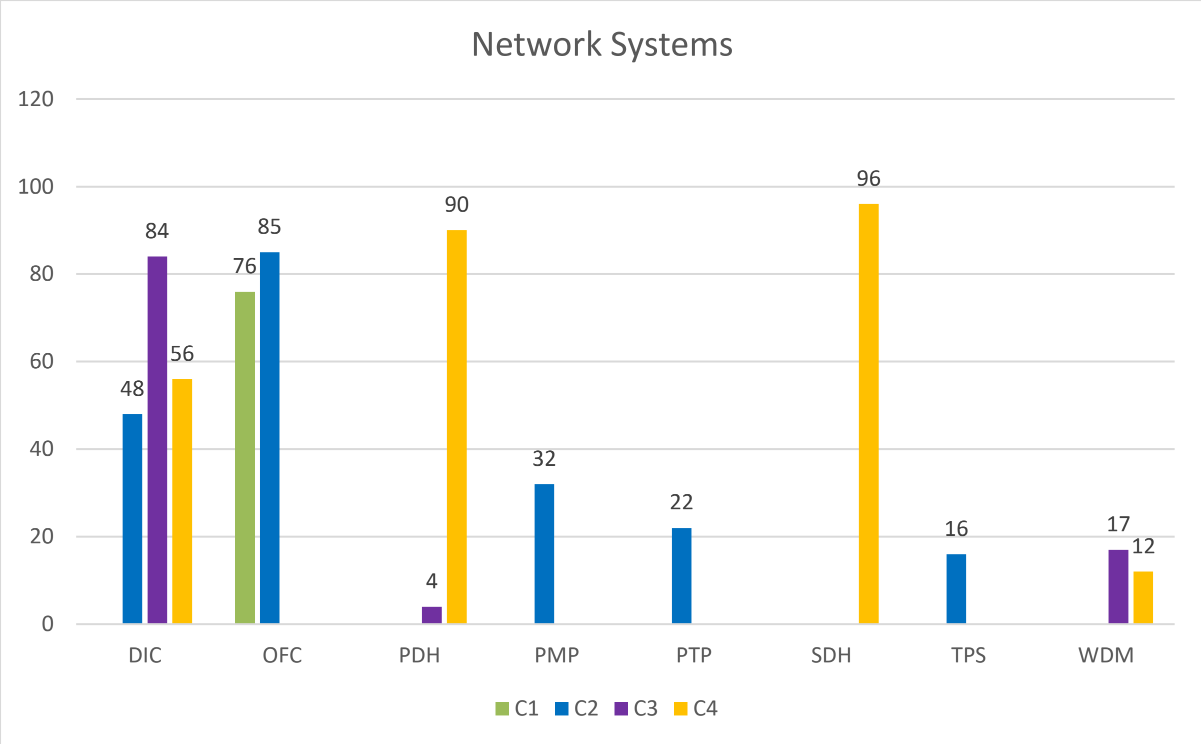

Figure 8 Communication Systems Condition Scores

3.3.1 Communications Bearers

The condition score for Communication bearers in Figure 8 shows that PTP and OFC technologies have scores of C2 and C1 respectively. This implies there is minimal deterioration and the assets follow recommended maintenance regimes.

3.3.2 Wireless Technologies

Whereas the condition of a TRIO remote or 3G modem is assessed as part of the pole-top control box, the condition of point-to-multipoint base radios and the 3rd party head-end systems have a direct impact on the remotes. The proposed shutdown of the 3G network will shift all the 3G modems to condition C5 because the existing modems will not work with the new upgraded systems.

3.3.2.1 Point to Multipoint TRIO Radio

Point-to-Multipoint radio base stations have a condition score C2. C2 condition score indicates minimal deterioration.

3.3.2.2 Operational Management Network (Wireless Access)

Wireless Access to the Operational Management Network (OMN) is achieved via [C.I.C] modems. Condition assessment C3 which indicates support is becoming limited.

3.3.3 Wireline Technology

3.3.3.1 Operational Data Network (ODN)

Operational Data Network (ODN) consists of PDH, SDH, WDM and Tele-protection systems. Figure 8 shows that 90 PDH systems have a condition score C4 and four systems have condition C3. SDH systems have a score of C4, 12 WDM systems have a score of C4 and 17 systems C3. TPS systems have a score of C2.

The condition C4 assets have limited spares and support from the manufacturers.

3.3.3.2 Operational Management Network (OMN)

The OMN (provided by DIC systems) includes routers, switches and serial servers. Figure 8 shows that 56 systems are in condition C4, 84 systems in condition C3 and 48 systems in C2. A breakdown of the systems contributing to the condition scores is shown in Figure 9 below.

[C-I-C]

C.I.C

Figure 9: Operational Management Network Asset Condition Summary

3.3.4 Telephony Technologies

The condition assessment score for the telephony systems is shown in Figure 10. Turrets, TMR fleets, and head-end are in condition C5. All other assets are in condition C1 to C3.

Turrets and TMR models have been discontinued and manufacturer support is limited. Spares are limited and not readily available.

C-I-C

Figure 10: Telephony Asset Condition Summary

3.3.5 Supporting Infrastructure

Field inspections have indicated that the antennas are in good condition.

3.3.6 Operational Support Systems

Operational support systems are evaluated as part of the physical system it supports.

3.3.7 Security Systems and Services

Condition of Security systems is analysed under the ICT Security systems

3.4 Asset Criticality

The communication system provides services for power system protection, SCADA, Control (DFA), and telephony. As an enabler, failure on its own has minimal to no impact on the supply of electricity to customers under normal electricity network operating conditions.

However, under electricity network fault conditions, unavailable communication systems will affect the duration of outage and the number of customers without supply in one or several of the following:

- failure of protection schemes which require information from remote sites to operate and therefore impacting value of unserved energy
- Inability of SCADA master to get or send information to field devices. This results in electricity network control reverting to manual operations and leading to an increase in the number of resources to manage the electricity network. The value of unserved energy increases because of longer duration required to restore power
- SCADA master unable to initiate DFA operations to reconfigure the network and therefore failure to minimise the number of customers without supply
- Inoperable REFCL systems which could result in a safety incident
- Failure of maintenance crew to communicate with CEOT resulting in delayed or suspended maintenance activities

3.5 Asset Performance and Risk

Failure mechanisms associated with communication systems include excess mechanical stress, fatigue, creep, wear, corrosion, temperature, overcurrent, overvoltage, and human error. These mechanisms lead to open circuits, short circuits, cracks, breaks, intermittent operations, and no outputs.

Apart from optical fibre cables and antennas, the majority of systems have electronic components and by nature of the complexity of electronic systems, failures at the system level do not follow a known failure curve. The majority of communication systems have random failure characteristics and have constant failure rates, as long as the operating environments conforms to the recommended specifications. However, under some circumstances, environments do not meet specifications as recommended and systems get exposed to high/low temperatures, moisture, vermin, and accidental damage.

3.5.1 Performance

Cables and Antennas

The majority of optical fibre cable runs are strung on electricity network poles and where not practical, like road crossing or major urban areas, the cables are run underground. The main cause of failure is cable breaks due to cars and tracks knocking down poles, pulling down cables that run across roads, or damage during excavations.

Antennas experience damage due to breaks emanating from mountings failure, excessive mechanical stress due to wind or snow, and corrosion.

Other Systems

Equipment with electronic parts are mainly damaged by external factors. High or low temperature due to failed air conditioners or clogged filters, short or open circuits due to vermin, lightning strikes, or human error.

3.5.2 Risk Analysis Methodology

AusNet Services employs dependability modelling based on the Reliability Centred Maintenance (RCM) standard to manage the electricity assets. Models are developed using Isograph's Availability Workbench (AWB) Software program.

Using failure modes as explained in section 3.5.1 and criticality discussed in section 3.4 modelling in AWB calculates risk scores for assets categorised on the five point Likert scale shown in Table 9

Asset Risk Score	Description	10 year cost range	Annual Avg. cost range
R5	Very High	$1,000,000 +	$100,000 +
R4	High	$100,000 – $999,999	$10,000 – $99,999
R3	Moderate	$1,000 – $99,999	$100 – $9,999
R2	Low	$100 - $999	$10 - $99
R1	Very Low	$0 - $99	$0 - $9

Table 9 Risk Score Scale

Communication systems risk scores were determined in ***AMS Continual Improvement Report: Evaluation of Risk Analysis for Communication Assets***. A summary of the electricity distribution assets is shown in Figure 11.

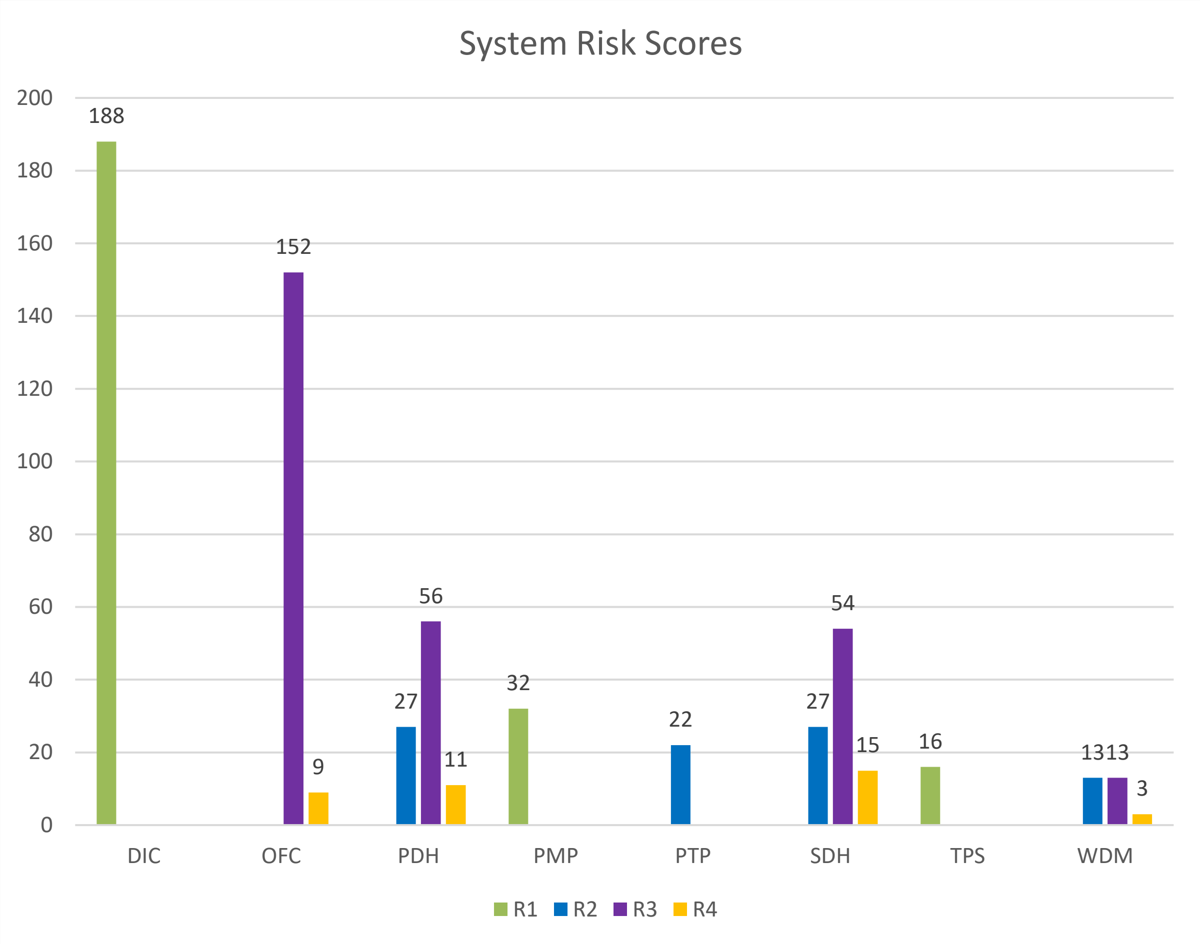

Figure 11 Electricity Distribution Communication Assets - Risk Scores

The telephony systems have been assessed separately based on CEOT operations. The risk score for telephone exchanges and the TMR Headend is estimated to be R3.

Antenna system risk scores are associated with the parent radio terminal.

Whereas TRIO and 3G modems are evaluated as part of pole-top control box, the impending change in technology of the 3G network (discussed in section 4.2) will affect all 3G modems and hence the proposal is to assign the headend 3G network risk to the modems.

4 Other Issues

4.1 Legislation and Regulatory Requirements

As an Electricity Distribution Network Service Provider (DNSP) in Victoria, AusNet Services must meet obligations stipulated in the National Electricity Rules, Electricity Distribution Code, and Electricity Safety Act. In particular, this strategy is developed to ensure AusNet Services complies with the following clauses and/or sections:

- National Electricity Rule (Clause 6.5.7)
- Electricity Distribution Code (Section 3.3.1(b))
- Electricity Safety Act (Section 98(a))

4.2 Technological Issues and Drivers

4.2.1 Legacy Systems

The communications network is made up of devices from multiple vendors with the expectation of the devices exchanging information seamlessly. However, interoperability challenges arise due to changes in proprietary protocols, vendor specific features and varying advances in the evolution of technologies between manufacturers. Managing multiple network technologies from different vendors is becoming increasingly challenging and generally does not provide the necessary economies of scale in the longer term. A strategic objective of AusNet Services is to build efficient automated and integrated processes and systems to support a dynamic business model.

PDH and SDH are now considered legacy technologies and the development of this technology is gradually diminishing. The Cisco switches model 3750 and 3550 have been discontinued and the manufacturer does not provide patches and longer. TRIO, WiMax and 3G are three technologies used in the AusNet Services wireless space. Industry suggests that wireless technology is moving towards new technology, like 5G, with development of the older technologies being scaled down. It is envisaged that 3G will be decommissioned within the next five years.

Support and spare parts for legacy systems quickly become scarce and often requires a long term financial commitment to a supplier to maintain stock of the required spare parts. This is not always economic and the long delays experienced in obtaining support or spares introduces an increasing risk of affecting the availability of the communication network.

On the telephony side, TDM based telephony systems (e.g. PABX) are becoming increasingly difficult to maintain as these technologies are migrating to packet based VoIP equivalents. Similarly, analogue signal based ‘Plain Old Telephone Services’ (POTS) are also becoming increasingly difficult to support as systems are replaced by the likes of NBN and VoIP service. Office locations and operational sites are being impacted by the reduced maintenance support and require migration of existing analogue Telecom services to digital NBN based equivalents.

4.2.2 Performance and Architecture

The AusNet Services wireline networks have grown from a small number of remote sites to a substantial number over the past 12 years, expanding in size to what was initially not anticipated. The existing approach to custom building is no longer sustainable or economic. It creates multiple layers of complexity across multiple networks and affects the performance of end users and network security.

TRIO Wireless Technology has experienced some operational issues and drawbacks limiting the usability. TRIO diagnostic and monitoring tools aren’t compatible with the rest of the tool-set and take a longer time to debug faults. Testing and commissioning also takes a longer time for TRIO compared to 3G, resulting in increased operating costs. Most importantly TRIO requires a longer time to propagate SCADA DB changes due to its point-to-multipoint nature and base station congestion.

The implementation of IEC 61850 is on the increase especially within the “smart” electricity network. In its current format the communication network cannot adequately accommodate the IEC 61850 requirements’ and changes need to be made in the ODN and OMN networks to support this capability.

4.2.3 Coverage

The AusNet Services’ Electricity Distribution communications network is supported by both AusNet Services owned systems and 3rd Party leased services. About 50 zone substations are connected by optical fibre whereas the majority of pole-top devices are connected via the 3rd party 3G services.

13 zone substations (BGE, BWA, CNR, LLG, MJG, MYT, NLA, PHI, SLF, SMR, WN, WYK, YEA) are not on the optical fibre network. However, renewable energy generation and sub-transmission line upgrades will require optical fibre installation at BGE, SMR, WYK, and YEA zone substations within the next 10 years.

4.2.4 Information Cyber Security Drivers

Industrial Control Systems (ICS) are defined as “a device, or set of devices, that manage, command, direct or regulate the behaviour of other devices or systems”.

This over-arching terminology incorporates all operational communication systems used in the electricity distribution network, including Distributed Control Systems (DCS), Process Control Systems (PCS), Energy Management Systems (EMS), Building Management Systems (BMS), Safety Instrumented Systems (SIS) and Supervisory Control and Data Acquisition Systems (SCADA).

The ICS may be targeted by malicious individuals for a range of reasons including financial gain, corporate espionage, or terrorist activities. Of increasing concern is a trend of foreign countries performing cyber espionage in preparation for cyber-warfare[1]. To combat this, the AusNet Services Information Security team is focussed on ensuring that new deployments are implemented with adequate security controls, and ensuring that existing controls are adequate to protect against current threats. In the event of network/application compromise, the goal of cyber-security infrastructure and controls are to ensure that issues are identified quickly, contained and recovered so that the damage or outage to the electricity network is minimised.

This is achieved by a combination of periodic testing, and "Defence in depth" controls:

- Periodic penetration tests (white hat hacking) provide a realistic view of the IT security posture. AusNet Services conducts such tests at least annually from a panel of external testers. Additionally, the information security team is well-versed in penetration testing activities. The strategies identified in this AMS are derived from known weaknesses identified via this testing and architecture review process.
- 'Defence in depth' is a strategy that provides multi layered controls (Malware prevention controls, Remote access and authentication controls, 802.1X technology controls and Network segmentation using VLAN, Role Based Access Control) and therefore greater protection if a breach occurs.

To detect attacks, detection tools and centralised management via Security Information and Event Managers (SIEM) are required. These tools provide automated threat forensics and dynamic malware protection against advanced cyber threats. The SIEM toolsets incorporate threat intelligence derived from Identifiers of Compromise (IoCs) discovered at other utilities and organisations around the world in defending similar threats.

Cyber-security guidelines, the most notable of which is the IEC 62443 standard for control system security combined with the NERC-CIP mandated requirements are considered in the development of this AMS to implement suitable controls for securing the remote ICS infrastructure.

5 Risk Management Options

Document ***AMS Continual Improvement Report: Evaluation of Risk Analysis for Communication Assets*** provides guidelines on the options for managing risk of Communication assets. The risk score and asset condition score are combined as shown in the Table 10 below to select the most appropriate alternative.

Asset Risk Score	Asset Management Guidelines				
	C1	C2	C3	C4	C5
R1	*No Action*	*No Action*	*Inspection*	*Inspection*	*Inspection*
R2	*No Action*	*No Action*	*Inspection*	*Inspection*	*Inspection*

[1] Data Breach Investigation Report (***Verison,*** 2014)

Asset Risk Score	Asset Management Guidelines				
	C1	C2	C3	C4	C5
R3	*Design Investigation*	*Inspection* *Condition Monitoring* *Functional Tests*	*Inspection* *Condition Monitoring* *Functional Tests*	*Schedule restoration or replacement*	*Schedule restoration or replacement*
R4	*Design Investigation*	*Inspection* *Condition Monitoring* *Functional Tests*	*Schedule restoration or replacement*	*Schedule restoration or replacement*	*Schedule restoration or replacement*
R5	*Design Investigation*	*Inspection* *Condition Monitoring* *Functional Tests*	*Schedule restoration or replacement*	*Schedule restoration or replacement*	*Schedule restoration or replacement*

Table 10: Asset Management Guidelines[2]

[2] AMS Continual Improvement Report: Evaluation of Risk Analysis for Communication Assets

5.1 Risk Scores and Condition Scores

A summary of condition scores obtained from the Asset Health Report and risk scores calculated for the distribution assets in ***AMS Continual Improvement Report: Evaluation of Risk Analysis for Communication Assets*** are shown in Table 11 and Table 12

Asset Type	Number of Assets				
	C1	**C2**	**C3**	**C4**	**C5**
DIC		*48*	*84*	*56*	
PDH			*4*	*90*	
SDH				*96*	
WDM			*17*	*12*	
TPS		*16*			
OFC	*76*	*85*			
PTP		*22*			
PMP		*32*			
Exchanges and TMR			*9*		*257*

Table 11: Number of Assets for given Condition Score

Asset Type	Number of Assets				
	R1	**R2**	**R3**	**R4**	**R5**
DIC	*188*				
PDH		*27*	*56*	*11*	
SDH		*27*	*54*	*15*	
WDM		*13*	*13*	*3*	
TPS	*16*				
OFC			*152*	*9*	
PTP		*22*			
PMP	*32*				
3G Network, Exchanges and TMR LDT			*22*		
TMR handsets	*245*				
3G Modems	*2014*				
TRIO Remotes	*182*				

Table 12: Number of Assets for given Risk Score

Whereas the condition of remote modems and TRIO remotes is determined with the associated control box, technological changes and closure of the current 3G network proposed by the 3rd Party provider of 3G will force the condition of 3G modems to C5 because the existing modems are not compatible with the new network. Table 13 depicts the condition scores including remote modems and the TRIO remotes.

Risk scores vary in step with the electricity network changes. The scale of REFCL systems is expanding and the need for protection systems required for connecting renewable energy generators is growing, this means that the criticality of communication systems and in particular DIC systems will increase.

The risk score associated with remote modems and the TMR handsets is estimated to be similar to the risk associated with the headend of the 3rd Party network because of the impending changes to be implemented by the 3rd party providers. Table 14 shows the forecasted risk scores including remote modems and TMR handsets.

Asset Type	Number of Assets				
	C1	**C2**	**C3**	**C4**	**C5**
DIC		*48*	*84*	*56*	
PDH			*4*	*90*	
SDH				*96*	
WDM			*17*	*12*	
TPS		*16*			
OFC	*76*	*85*			
PTP		*22*			
PMP		*32*			
Exchanges and TMR			*9*		*12*
TMR Handsets					*245*
3G Modems					*2014*
TRIO Remotes			*182*		

Table 13: Number of Assets for given Condition Score Including Remotes

Asset Type	Number of Assets				
	R1	**R2**	**R3**	**R4**	**R5**
DIC		*100*	*88*		
PDH		*4*	*79*	*11*	
SDH		*6*	*75*	*15*	
WDM		*13*	*13*	*3*	
TPS	*16*				
OFC			*152*	*9*	
PTP		*22*			
PMP	*32*				
Exchanges and TMR			*21*		
TMR handsets			*245*		
3G Modems			*2014*		
TRIO Remotes	*182*				

Table 14: Number of Assets for given Risk Score Including Remotes

The number of assets resulting from the combination of risk score and condition score matched to the asset management guidelines is shown in Table 15 below.

Asset Risk Score	Number of Assets				
	C1	**C2**	**C3**	**C4**	**C5**
R1		*48*	*182*		
R2		*72*	*57*	*16*	
R3	*67*	*83*	*57*	*209*	*2271*
R4	*9*			*29*	
R5					

Table 15: Projected Number of Assets for given Risk Score and Condition Score

5.2 Risk Based Asset Management Options

5.2.1 Design Investigation

There are 76 assets falling under this group. All the assets are OFC (cables) a reflection of the fact that it is an aggregation point for services running between sites.

5.2.2 Condition Monitoring/Function Test/Inspection

There are 395 assets which should continue to be inspected and monitored

DIC Systems	92
PDH Systems	4
SDH Systems	6
WDM	17
Exchanges	9
TRIO Remotes	182
OFC	85

5.2.3 Replacement

2509 assets are recommended for replacement

PDH	90
SDH	90
WDM	12
DIC systems	46
TMR	12
TMR Handsets	245
3G Modems	2014

5.2.4 No Action

The combination of risk and condition recommends no action for 120 assets

TPS	16
PTP	22
PMP	32
DIC	50

6 Strategies

- The financial analysis of the strategies identified below is based on the AusNet Services Risk Assessment Process & Criteria (RM 10-01-1) which defines consequence criteria ratings, and the AusNet Services Corporate Net Present Value (NPV) model. The inputs to the financial analysis are obtained from the following information.
- A communication system failure on its own does not interrupt the supply of electricity to customers, however, the combination of an electricity network fault and a communication system failure could result in supply interruptions. When a fault occurs and there is no communication, some power system protection relays, SCADA, DFA, and REFCL will not operate.

- Protection relay and REFCL systems failure result in immediate consequences to supply failure, but SCADA and DFA application failures increase the duration and number of customers without supply because network control reverts to manual operations.
- The 10-year average of feeder faults across the AusNet Services electricity network is 15 per year and historical maintenance data of the communication systems in AusNet Services estimates a repair rate of 10 per year. Assuming the communication system failures and electricity network outages are random and independent in nature there is a chance of electricity network faults coinciding with a failure of the communication network.

6.1 Bearers

The bearers fall into two categories of risk management; design investigation and no action. The design investigation is for optical fibre bearers. Duplication of fibre routes will reduce the risk associated with the fibre route.

Possible solution is to investigate new or upgrades of 66kV and 22kV lines.

- New or Upgrade of 66kV construction designed with earth-wire
- Replace earth-wire with OPGW
- New 66kV (without earth-wire) and/or New 22KV construction
- Include ADSS on the poles
- Estimated cost
- Cost associated with this option would be included in the new or upgrade of the line

6.2 Wireless Technology Strategy

Wireline technologies include TRIO base radios, 3rd Party 3G network, and remote modems. According to the risk management options, The PMP radios and TRIO remotes should be monitored and inspected. However, technological changes proposed by the 3rd Party 3G service provider will force an upgrade of the existing 3G modems within the next five years.

- Transition program from 3G to 4G/LTE starts in financial year 2021/22 and runs for three years. 786 modems replaced in year one and year two and the final 478 modems replaced in year three.
- Estimated cost over the three years

FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	Total
C.I.C					

Financial assessment using the NPV model results are shown in Figure 12 below

C.I.C

Figure 12 NPV Model Wireless Technology

Two option were considered

- Replace on failure (BAU)
- Programmed Replacement (preferred option)

6.2.1 Option 1 – Replace on Failure (BAU)

This option proposes to maintain equipment using existing network. When the 3G network is decommissioned, alternative modems are evaluated and deployed.

6.2.1.1 Analysis

- Selecting this option leads to:
- High capital expenditures because of high unplanned replacement costs. Typically, unplanned replacement attracts between 30% - 50% premium of a planned expenditure
- Longer lead times translate to longer equipment outage time and potentially longer supply outage

6.2.1.2 Result

Capital expenditure with a premium cost because of the unplanned nature of the work.

Potentially longer delays because of duration to mobilise resources when failures occur. This will contribute to value of unserved energy.

6.2.2 Option 2 – Planned Replacement (Preferred Option)

This option targets to replace assets based on the risk of the asset to maintaining supply to customers.

6.2.2.1 Analysis

Implementing this option will enable:

- Targeting assets with greatest impact to customer outages
- Schedule replacements based on 3rd Party decommissioning plan

6.2.2.2 Result

There is no step change to operational costs and potentially similar outage durations as current.

6.3 Wireline Technologies Strategy

- The risk management options for wireline technology systems includes:
  - No Action — 50 DIC, 16 TPS systems, 32 PMP and 22 PTP systems
  - Function Test/Inspection — 92 DIC systems, 4 PDH, 6 SDH, 17 WDM, 182 TRIO Remotes
  - Replacement — 90 PDH, 90 SDH, 12 WDM, 46 DIC systems
- Carry out inspections and functional tests
- Modify the Communication Design Standard to support IEC 61850 within zone substations and between zone substations
- Develop and implement relevant Communication Network Architecture
- Replace systems over a five-year period; about 35 systems per year in the first three years and then 65 per year for the final two years
- Estimated costs
  - No step change expected for the inspection and testing of systems
  - Capital investment over a five-year period

FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	Total
		C.I.C			

A financial analysis considering four options was performed and the results of the NPV model are shown in Figure 13 below

C.I.C

Figure 13 NPV Model Wireline Technology

The four options considered;

- No Replacement
- Replacement on Failure
- Planned Replacement (preferred)
- 3rd Party Provider Services

It should be noted that because of technical limitations of 3rd Party networks to support power system protection signalling the financial analysis was not performed.

6.3.1 Option 1 – No Replacement (BAU)

Operate and maintain existing systems until spares and support is not available and abandon the network.

- Drawdown on spares to maintain and operate the existing equipment
- No replenishment of spares because the system is obsolete and spares are not manufactured
- Diminished external support because manufacturers have other products or abandoned the market
- Abandon systems when repairs are not possible

6.3.1.1 Analysis

This option will expose customers to longer supply outages than current levels. Shortcomings of this option include:

- Limited manufacturer support for obsolete equipment gradually increases operational and maintenance costs
- Scarce resources leading to;
- SCADA application outage and hence longer customer outage time in case of electricity network faults
- Unavailability of DFA application and therefore inability to switch customers in case of a fault
- The communication network collapses when spares are depleted - the consequence being a switch of electricity network control to manual operations
- SCADA application fails and field operations become manual
- DFA application is not available and switching of customers when faults occur becomes a manual process

6.3.1.2 Result

No capital expenditure however substantial level of operational expenditure to maintain the equipment until complete shutdown. Parts produced on special order attract a premium, reverse engineering to obtain replacement parts is expensive and time consuming.

Potentially longer delays will contribute to value of unserved energy and in the case of REFCL or protection this could result in safety impacts.

6.3.2 Option 2 – Replace Equipment on Failure

This option proposes to maintain equipment using existing spares and when spares are exhausted, failed equipment is replaced with similar equipment. The process in this option dictates that:

- Drawdown on spares to maintain and operate the existing equipment
- When spares are depleted, replace failed equipment with similar equipment until such a time similar equipment cannot be obtained

6.3.2.1 Analysis

Selecting this option leads to:

- An increase in operational and maintenance costs for in-service equipment but as the old equipment gets replaced with new equipment the operational cost is expected to reduce
- High capital expenditures because of high unplanned replacement costs. Typically, unplanned replacement attracts between 30% - 50% premium of a planned expenditure
- Increased cost of replacement equipment – equipment produced on special order because vendor has stopped regular manufacture of the model
- Longer lead times translate to longer equipment outage time and potentially longer supply outage
- Incorporating new applications like smart meters and protection signalling for new generators at the distribution level could lead to decommissioning newly installed replacement equipment or duplication of equipment because current equivalents may not be suitable for these applications

6.3.2.2 Result

Capital expenditure with a premium cost because of the unplanned nature of the work. Increase in operational expenditure to test in-service service systems. However, the operational costs will gradually reduce as obsolete equipment is replaced.

Potentially longer delays because of duration to mobilise resources when failures occur. This will contribute to value of unserved energy and in the case of REFCL or protection could result in safety impacts.

6.3.3 Option 3 – Planned Replacement (Preferred Option)

This option targets to replace assets based on the risk of the asset to maintaining supply to customers.

- Identifying high risk assets
- Finding modern equivalents of existing equipment
- Considering new applications such as new generators, smart metering and REFCL

6.3.3.1 Analysis

Implementing this option will enable:

- Targeting assets with greatest impact to customer outages
- Identifying modern equivalents capable of incorporating new applications like SMART meters, and protection signalling for generators and avoiding duplication of equipment or decommissioning newly installed systems

6.3.3.2 Result

There is no step change to operational costs and potentially similar outage durations as current.

6.3.4 Option 4 – Third Party Services

This option proposes to migrate the communication services to a 3rd Party Service provider like the National Broadband Network (NBN), Telstra or Optus.

- Telephony, SCADA and DFA services, can be provided by 3rd Party Providers. Currently, some telephony, majority of pole-top devices and some remote access services are provided by 3rd parties. However, power system protection signalling required for the 66kV sub-transmission lines, and possible connection to renewable energy generation sites cannot reliably be provided by a 3rd party provider. Protection systems require high availability and deterministic communication channels which are not guaranteed by 3rd Party Providers.
- No financial analysis performed on this option because it does not sufficiently meet the requirements of running and managing a reliable electricity network.

6.4 Telephony Technologies Strategy

A separate assessment to determine risk scores for telephony technologies was performed, with the risk associated with exchanges and the TMR headend estimated from the view point of the CEOT. The risk management options for telephone proposes to monitor and inspect the nine exchanges, and replace the TMR headend and the TMR handsets.

- Extend the coverage of Operational Telephony Network (OTN) system to zone substation, where there is no OTN extension at present
- Replace TMR Server and handsets
- Upgrade existing POTS line to new NBN Service
- Estimated costs
  - Capital investment over a five-year period

FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	Total
		C.I.C			

Financial assessment using the NPV model results are shown in Figure 14 below

C.I.C

Figure 14 NPV Model Wireless Technology

Two option were considered

- Replace on failure (BAU)
- Programmed Replacement (preferred option)

6.4.1 Option 1 – Replace Equipment on Failure (BAU)

This option proposes to maintain equipment using existing spares and when spares are exhausted, failed equipment is replaced with similar equipment. The process in this option dictates that:

- Drawdown on spares to maintain and operate the existing equipment
- When spares are depleted, replace failed equipment with similar equipment until such a time similar equipment cannot be obtained

6.4.1.1 Analysis

Selecting this option leads to:

- An increase in operational and maintenance costs for in-service equipment but as the old equipment gets replaced with new equipment the operational cost is expected to reduce
- High capital expenditures because of high unplanned replacement costs. Typically, unplanned replacement attracts between 30% - 50% premium of a planned expenditure
- Increased cost of replacement equipment – equipment produced on special order because vendor has stopped regular manufacture of the model
- Longer lead times translate to longer equipment outage time and potentially longer supply outage

6.4.1.2 Result

Capital expenditure with a premium cost because of the unplanned nature of the work. Increase in operational expenditure to test in-service service systems. However, the operational costs will gradually reduce as obsolete equipment is replaced.

Potentially longer delays because of duration to relay information between operational crews when failures occur.

6.4.2 Option 2 – Planned Replacement (Preferred Option)

This option targets to replace assets based on the risk of the asset to maintaining supply to customers.

- Identifying high risk assets
- Finding modern equivalents of existing equipment

6.4.2.1 Analysis

- Implementing this option will enable:
- Targeting assets with greatest impact to customer outages

6.4.2.2 Result

There is no step change to operational costs and potentially similar outage durations as current.

6.5 Supporting Infrastructure Strategy

- Monitor condition of antennas
- Regular check on licensed frequency allocation to maintain currency of antennas

6.6 Operational Support Systems Strategy

- Existing supporting tools to be kept current in line with vendor software version upgrades

6.7 Security Strategy

The AusNet Services' Information Security team strategy is to adopt the following initiatives based on the understanding that prevention is desirable, but detection is mandatory.

- Implement and Integrate SIEM visibility to ICS field deployments

– Continue implementation of Network Security Monitoring (NSM) and remote forensic investigation and reporting by SOC and InfoSec teams

– Continue implementation of anti-tamper alerts on all cabinets or rooms that house ICS equipment, Satellite, 3G/4G or radio gear used for ICS

– Implement Passive Vulnerability Assessment toolsets specifically for the ICS environment

- Implement centralised Authentication, Authorisation and Audit for ICS environment

  – Continue integration of auth-proxy to SIEM with audit tools to govern operational practices to remove, disable or rename default system accounts, enforce account lockout policies, and use of strong passwords and alert to SIEM

- Estimated costs

  – Capital investment over a five-year period

FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	Total
		C.I.C			

Financial assessment using the NPV model results are shown in Figure 15 below

C-I-C

Figure 15 NPV Model Security

Two option were considered

– Stop SIEM Integration (BAU)

– Continue Integration of SIEM Security (preferred option)

6.7.1 Option 1 – Stop SIEM Integration (BAU)

This option proposes to stop the SIEM integration for more devices.

6.7.1.1 Analysis

Selecting this option leads to:

- Some field devices are not monitored

6.7.1.2 Result

Potential vulnerability for external computer network attack.

6.7.2 Option 2 – Continue Integration of SIEM Security (Preferred Option)

This option continues the integration of SIEM to field devices and improvement of computer security

6.7.2.1 Analysis

Implementing this option will enable:

- Maintaining a secure computer network

6.7.2.2 Result

Security of the computer network is maintained

Appendix A List of Abbreviations

Abbreviation	Description
ACMA	Australian Communications and Media Authority
ADG	Asset Data Gathering
ADSS	All Dielectric Self Supporting
AEMO	Australian Energy Market Operator
AMI	Advance Metering Infrastructure
AMS	Asset Management Strategy
BMS	Building Management Systems
CEOT	Customer and Energy Operations Team
CWDM	Corse Wave Division Multiplexing
DCS	Distributed Control Systems
DWDM	Dense Wave Division Multiplexing
EDAMS	Electricity Distribution Metering Asset Management Strategy
EMS	Energy Management Systems
HMI	Human Machine Interface
HV	High Voltage
ICS	Industrial Control Systems
ICT	Information Communication Technology
IED	Intelligent Electronic Device
IoC	Identifiers of Compromise
IPVPN	Internet Protocol Virtual Private Network
LTE	Long Term Evaluation
MPLS	Multi-Protocol Label Switching
NAC	Network Access Control
NBN	National Broadband Network
NOC	Network Operations Centre
ODN	Operational Data Network
OMN	Operational Management Network
OPGW	Optical Fibre in Ground Wire
OSS	Operational Support Systems

Abbreviation	Description
OTN	Operational Telephony Network
PCS	Process Control Systems
PDH	Plesiochronous Digital Hierarchy
POTS	Plain Old Telephone System
PSTN	Public Switching Telephony Network
PTMP	Point-to-Multipoint
PTP	Point-to-Point
QoS	Quality of Service
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SIEM	Security Information and Event Management
SIS	Safety Instrumentation Systems
TDM	Time Division Multiplexing
TMR	Trunk Mobile Radio
TRIO	Point-to-multipoint RF wireless network
TS	Terminal Station
U/G	Under Ground
VLAN	Virtual Local Area Network
VoIP	Voice Over Internet Protocol
VPN	Virtual Private Network
VRLA	Valve Regulated Lead Acid
VSWR	Voltage Standing Wave Ratio
WDM	Wavelength Division Multiplexing
ZSS	Zone Substation