AMS 10-56 Communication Systems

2023-27 Transmission Revenue Reset

PUBLIC

Document number	AMS 10-56
Issue number	10
Status	Approved
Approver	S Dick
Date of approval	30/09/2020

ISSUE/AMENDMENT STATUS

Issue Number	Date	Author	Reviewed	Approved
0.1	23/09/2011	D. Ots	-	
0.9	13/11/12	D. Ots	-	T. Ton
1.0	20/11/12	D. Ots	-	T. Ton
1.1	3/12/12	D. Ots/D.P.	-	T. Ton
1.2	20/05/2015	D. Ots	-	T. Ton
1.3	17/07/2015	D. Ots	-	T. Ton
9	16/09/2015	T. Ton	-	T. Ton
10	30/09/2020	A. Nainhabo	T. Ton & A. Dickinson	S. Dick

Disclaimer

Contact

This document is the responsibility of the Network Management division of AusNet Services. Please contact the indicated owner of the document with any inquiries.

AusNet Services
Level 31, 2 Southbank Boulevard
Melbourne Victoria 3006
Ph. (03) 9695 6000

Table of Contents

List of Tables

List of Figures

1 EXECUTIVE SUMMARY

The communications systems in AusNet Services provide services which support electrical network protection signalling, power system monitoring and control, voice communication, and application data transfer.

Delivery of these services is governed by the requirements outlined in the National Electricity Rules.

Communication systems are of various technologies and can be categorised as bearers, network technologies and telephony systems. These systems are monitored and administered using software applications classified as operational support systems. Supporting infrastructure provides physical security for the assets and security systems provide cyber security.

The key issues facing communication systems are support from vendors for systems which have been declared end-of-support, and legacy systems which are not compatible with newer technologies. Cyber security has also become an area that needs to be considered given the possibility of external disruptions to the delivery of electricity by intruders.

The asset strategies aimed at addressing the key issues and maintaining the availability of the communication network at the current level are:

- Development of a “next generation” communications architecture
- Replacement of end-of-life systems
- Enhancing communications service cyber security systems

The strategies for each of the components of the communication systems are described in the following sections.

1.1 Bearer Strategy

- A minimum of two independent communications bearers to each EHV terminal station
- When selecting a new installation or replacing an existing bearer, the priority for options to be considered in the economic analysis will be as follows:

  Main route:

  – OPGW — AusNet Services owned fibre
  – Point-to-Point — AusNet Services owned digital radio
  – Underground — AusNet Services owned fibre
  – Power Line Carrier — AusNet Services owned

  Second route:

  – OPGW — AusNet Services owned fibre
  – Point-to-Point — AusNet Services owned digital radio
  – Underground — AusNet Services owned fibre
  – ADSS — AusNet Services owned fibre
  – Optical Fibre — Third Party
  – Power Line Carrier — AusNet Services owned

- Install OPGW in conjunction with planned EHV ground wire replacement programs
- Install OPGW fibre on new EHV line construction or refurbishments
- Replace end-of-life Point-to-Point radio links to modern equivalents
- Identify ongoing suitability of digital Power Line Carrier technology when other alternatives cannot be justified
- Establish condition monitoring for optical fibre cables

1.2 Network Technologies Strategy

- Identify and standardise suitable next generation WDM, SDH, PDH, and TPS systems
- Replace end-of-life SDH equipment with next generation equivalent
- Replace end-of-life PDH equipment with next generation equivalent
- Replace end-of-life WDM equipment with next generation equivalent
- Replace end-of-life Routers, Switches and Serial Servers with next generation equivalents
- Replace end-of-life Tele-protection equipment with new equivalent technology
- Update the communication Design Standard to support IEC 61850 applications
- Migrate 3G wireless technology to new equivalent wireless service

1.3 Telephony Strategy

- Identify opportunities for system consolidation considering business wide requirements
- Replace end-of-life PABX with new equivalents
- Replace end-of-life mobile radio handsets to new equivalents

1.4 Operational Support Systems Strategy

- Replace end-of-life network management systems hardware and software
- Develop a centralised network management system for both the OMN and ODN network devices

1.5 Supporting Infrastructure Strategy

- Replace antenna systems when necessary
- Replace C5 and C4 batteries
- Replace air conditioning systems based on site requirements

1.6 Security Strategy

- Implement user access control system – for users and devices
- Upgrade SIEM to latest capability
- Continue to improve the centralised Authentication, Authorisation and Audit for ICS environment

2 INTRODUCTION

2.1 Purpose

This document describes the Asset Management Strategies for Communication Systems in the AusNet Services Victorian Electricity Transmission Network.

The purpose of this asset management strategy is to provide an overview of the AusNet Services' existing communications technologies, assets, asset age profiles, asset condition, issues affecting performance of the assets, and strategic initiatives to address identified concerns.

In addition, this document forms part of the AusNet Services Asset Management System for compliance with ISO 55001 and relevant regulatory requirements. This document demonstrates responsible asset management practices by outlining economically justifiable outcomes.

2.2 Scope

This strategy applies to communication systems associated with the Victorian electricity transmission network grouped into:

- Bearers
- Network technologies
- Telephony technologies
- Gateway technologies
- Operational support systems
- Supporting facilities
- Security systems

The strategy does not cover supporting facilities associated with buildings and communication towers.

2.3 Asset Management Objectives

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

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

As stated in *AMS 10-01 Asset Management Strategy -Transmission Network*, the transmission network asset management objectives are:

- Maintain top quartile benchmarking
- Maintain reliability
- Minimise market impact
- Maximise network capability
- Leverage advances in technology and data analytics
- Minimise explosive failure risk

2.4 Reference Documentation

This asset management strategy forms part of a suite of documentation that supports the management of AusNet Services' assets, which include the following:

- AMS 10-68 – Asset Management Strategy – Secondary Systems
- AHR 10-56 – Communication System Asset Health Report – Transmission

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 information can be classified in any one of the following categories:

- Signalling
- Data
- Commands
- Voice

Protection devices use signalling to constantly exchange information over a communication channel and in the event of an incident, messages are exchanged so that appropriate protection devices operate to protect equipment and minimise the risk of injury.

Field devices, which include Remote Terminal Units (RTUs), line monitoring devices, and weather stations, send electricity network data to the Supervisory Control and Data Acquisition (SCADA) master or other master server and receive commands from the SCADA master to reconfigure the electricity network through communication channels.

The telephony system provides voice channels which enable operational teams to talk during periods of emergency or planned network maintenance work and allows customers to contact AusNet Services to report faults or emergencies.

Through communication systems, engineers and field teams can remotely access field devices and diagnose network failures or get access to network databases that are used to maintain the network and avoid multiple trips between the terminal station and depots or offices.

Video surveillance and site access applications are reliant on communication services to protect AusNet Services assets by sending video data to the security centre.

3.2 Asset Population

Various technologies are used to enable the provision of the communications services. The technologies can be generalised under the following headings:

- Bearers
- Network technologies
- Telephony technologies
- Operational support systems
- Supporting facilities
- Computer security systems

3.2.1 Bearers

Communication bearers provide the interconnectivity medium between physical locations. The bearers used in AusNet Services include:

- Optical fibre cables
- Power line carrier
- Point-to-point microwave radio

Where installation of AusNet Services bearers is not economic, third party services such as Asymmetric Digital Subscriber Line (ADSL), Broadband Digital Subscriber Line (BDSL), and Integrated Services Digital Network (ISDN) are used.

Optical fibre cables

Optical fibre transfers communication signals converted into light between sites. Fibre cores are bundled into three types of cables, listed in Table 1.

Table 1: Optical Fibre Cable Types

Type	Description
OPGW	Optical Ground Wire (OPGW) is optical fibre embedded in the earth-wire of the electricity grid. OPGW has expanded as aged earth-wires are replaced with OPGW
ADSS	All Dielectric Self Supporting (ADSS) is optical fibre and mainly strung on electricity poles. The AusNet Services ADSS network runs on poles in both AusNet Services and other Distribution companies
U/G OFC	Underground Optical Fibre Cable (U/G OFC) cables are buried in conduit and provide the interconnection of equipment in adjacent buildings or sites where overhead optical fibre is not practical

The cables are differentiated by the physical infrastructure that supports the cable. OPGW leverages the electrical network ground-wire and towers, ADSS is generally strung on poles or towers of networks below 132kV, and underground fibre is buried in conduits.

Optical fibre provides the highest data bandwidth capabilities compared to other bearers and is relatively immune to environmental conditions such as electrical noise.

Power line carrier

Power Line Carrier (PLC) systems use phase conductors of the transmission line to transfer signals. The signal is modulated onto Extra High Voltage (EHV) lines to enable signalling between the two ends of a line. PLC provides the least bandwidth compared to the other bearers in AusNet Services.

PLC systems are being phased out and remain in areas where optical fibre or radio bearers are not economical.

Point-to-point microwave radio

Point-to-point (PTP) radio uses electromagnetic waves to transfer data between sites. AusNet Services uses the licenced band for the microwave network to avoid interference. Radios are primarily used to provide redundancy.

3.2.2 Network Technologies

Network technologies provide a physical interface for the user to access the communication network. The multiple services are combined into one signal and sent to the bearers for transfer to the next physical location.

AusNet Services has three networks that support the various applications depending on specific requirements and interface specifications:

- Operational Data Network (ODN)
- Operational Management Network (OMN)
- Corporate Network

Table 2: AusNet Services' Networks

Type	Description
ODN	The ODN is the most critical communication network for AusNet Services' operations. The network provides services for power system protection, SCADA, and the operational telephone system. The technologies used for this network include Tele-protection Systems (TPS), Plesiochronous Digital Hierarchy (PDH), Kilomux (HMX), Synchronous Digital Hierarchy (SDH), and Wave Division Multiplex (WDM)
OMN	The OMN provides services for remote management of devices, access to corporate systems, video monitoring, and electronic access and logging for sites. The technologies used in this network consist of Digital Interface Cubicle (DIC) which comprises switches, routers, and modems.
Corporate Network	The Corporate network provides services for offices and depots. The systems used in this network consist of switches, routers, and modems.

These networks use interconnected communications systems shown in Table 3 to accomplish the establishment of required channels.

Table 3: Network Technologies

Type	Description
PDH	PDH provides physical and virtual interconnection of communication channels on the access layer. The PDH provides interfaces which include V24, V28, G703, and C37.9
HMX	HMX provides physical and virtual interconnection of communication channels on the access layer. The PDH provides interfaces which include V24, V28
SDH	SDH uses time division multiplexing (TDM) to aggregate multiple communication channels and convey the message over a single physical link. In most cases the physical link is optical fibre but PTP radio can also be used
WDM	WDM uses light and time division multiplexing (TDM) to aggregate multiple communication channels and convey the message over an optical fibre link. WDM is used to augment the SDH systems where the distances are beyond SDH limits or where optical fibre cores are limited
DIC	Provide user interfaces that require Ethernet technology. The switches and routers connect to SDH or WDM systems for onward transfer of the data
Data Modems	Data modems connect users to third party networks – typically 3G and 4G networks

3.2.3 Telephony Technologies

Telephony is divided into three systems:

- Operational telephony
- Business telephony
- Customer telephony

Business telephony and customer telephony form part of the ICT Strategy and are not included in this strategy. Table 4 lists the assets used to establish the operational telephony system.

Table 4: Operational Telephony System Assets

Type	Description
PABX	PABX provide a switching function in voice communications and interface with the handsets at terminal stations. PABX are connected to network technologies which provide connection between exchanges.
Consoles	Console systems provide a front end to voice and mobile radio communications in Customer and Energy Operations Team (CEOT). Features include managing and prioritising operational calls to and from the control room.
Mobile Radio	A third party public wireless network providing emergency radio communications to 95% of the state. Used for voice communication where service coverage or performance by other services is limited.

3.2.4 Operational Support Systems

Operational Support Systems are software applications which include Network Management System (NMS) and Element Management Systems (EMS).

Operational Support Systems monitor the communications systems and facilitates remote access for maintenance and administration.

3.2.5 Supporting Facilities

Supporting facilities provide the secure environment required to operate communication systems. These systems do not carry communications traffic but house or protect the communication systems.

Table 5 describes each of the supporting facilities.

Table 5: Supporting Facilities

Type	Description
Towers and poles	These assets are used to hold antennas and waveguides. The asset strategies governing towers and poles are included in the Lines strategy
Antennas	Antennas receive and guide the electromagnetic waves generated by point-to-point radio system between sites
Buildings	Buildings accommodate communication equipment and protect the equipment from the elements. Buildings are enclosed in fencing and have security systems to protect against vandals and saboteurs. The asset strategy for buildings is explained in AMS 10-55 *Civil Infrastructure*.
DC supply systems	DC supply systems provide the necessary power for communication systems. Batteries, chargers, AC-DC converters, DC-DC converters, solar panels, and diesel generators are the main components of DC systems. The asset strategy for these assets is included in the Transmission Auxiliary Power systems strategy.
Air conditioning systems	Air conditioning systems maintain the temperature in buildings to within limits required for communication systems to operate optimally. The asset strategy for these assets is included in the Civil Infrastructure strategy.

3.2.6 Computer Security Systems

Computer security systems protect the communication network from malicious external attacks.

Security systems strategy associated with devices is included in the ICT strategy.

3.2.7 Asset Quantities

The AusNet Services electricity transmission network has communication assets at approximately 111 geographical locations (terminal stations, control centres, data centres, and administrative offices) as shown in Table 6.

Table 6: Communication Asset Geographical Locations

Communication Asset Locations	Sites
Terminal Stations	46
Radio Sites	30
Data Centres	2
Control Centres	1
Offices and Depots	6
Other non-AusNet Services Sites	26
Total Communication Sites	**111**

The list of assets and estimated quantities for each asset group is provided in the tables below.

Table 7: Communication Bearers

Group	Type	Length/Quantity
Optical Fibre Cable	OPGW	2,637 km
	ADSS	230 km
	Underground	2 km
Point-to-Point Radio Links		85
PLC Nodes		91

Table 8: Network Technologies

System	Quantity
PDH	463
SDH	190
WDM	58
TPS	447
Routers	29
Serial Servers	208
Switches	399
Engineering Server	18
3G Modems	16

Table 9: Telephony Assets

System	Quantity
Exchanges	43
Consoles	5
Mobile radios	50

Table 10: Supporting Infrastructure Assets

Systems	Quantity
Antennae	260

3.3 Asset Age Profile

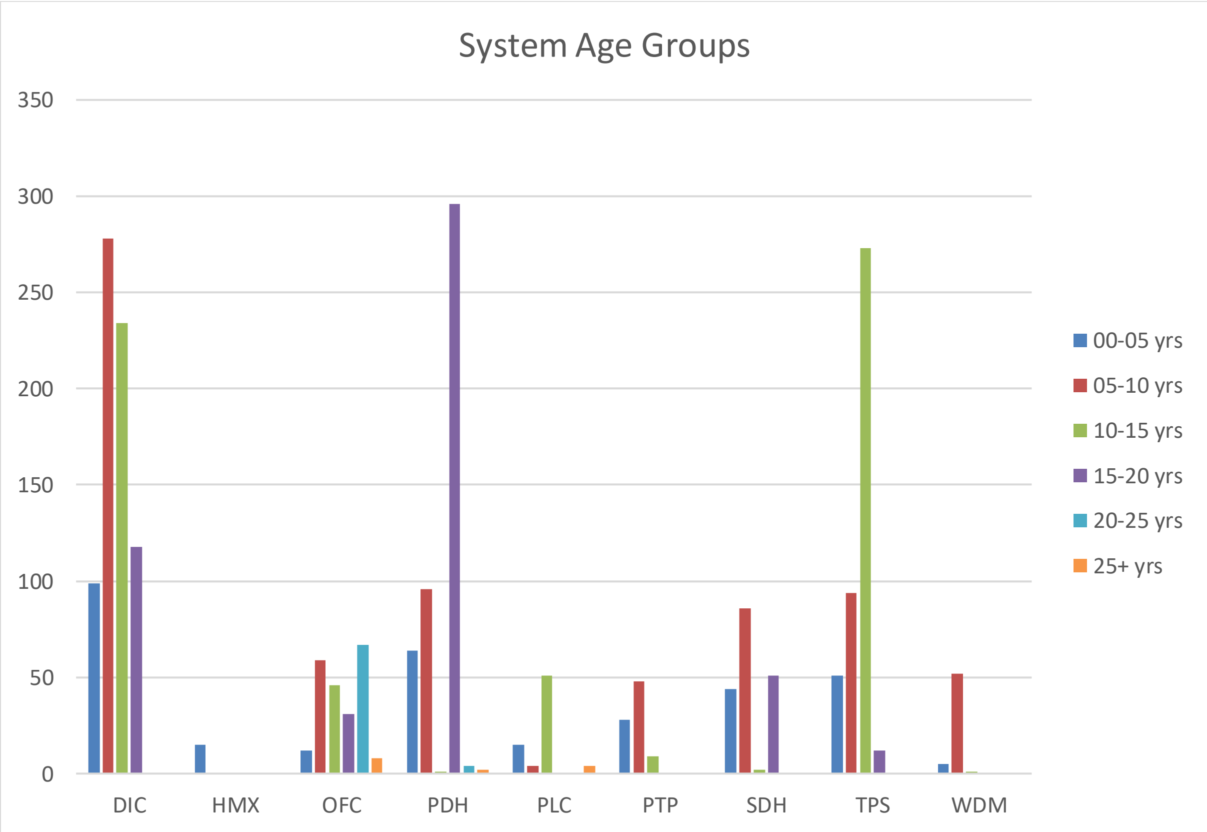

Figure 1: System Age Profiles

3.4 Asset Condition

The asset condition score is a calculated value which gives an indication of the proximity to end-of-life of an asset. The calculation is based on

- the components of an individual asset
- factors which affect a fleet or model
- the working environment conditions in which the asset operates

The values used to calculate the asset condition are captured through measurement points shown in Table 11.

Table 11: Source of Measurement Points

Measurement Point	Element	System/Subsystem/Boundaries
Establishment	Working Environment	Air conditioning system
		Cable trays, cubicles, cabinets
		Vegetation clearance
Obsolescence	Asset Function	Delay, losses
		Interfaces
		Bandwidth
	Spares	AusNet Services stores
		Other sources
	Support	Internal skills
		External skills and support
	Technology	Capacity
		Operating costs
		Maintenance cost
Economic	Planned Maintenance	Maintenance work orders
	Failure Rate	Repair or emergency work orders
Safety and Environment	Health and Safety	Compliance with Mission Zero
	Ecological	Environmental requirements
	Legislative	Industry regulations
		Federal and State laws
Usage	Utilisation	Channels, ports, extensions
		Wavelengths, bandwidth
		Copper pairs, Fibre Cores
		Power output
Degradation	Maintenance and Inspection	Physical Attribute and measure

The measurement points are used to calculate a condition score. The interpretation of the score results is summarised in Table 12.

Table 12: Asset Condition Score

Condition	Description	Explanations	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%

As shown in the summary of the Asset condition scores Figure 2.

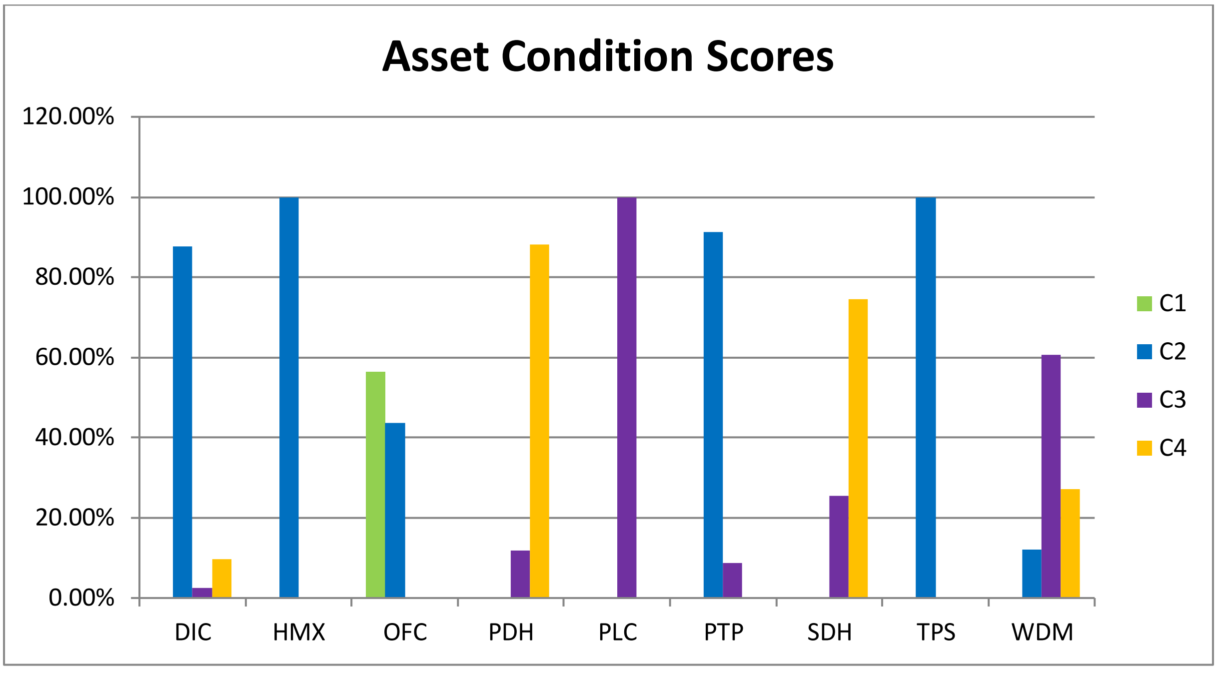

Figure 2: System Condition Scores

Approximately 88% of PDH systems, 75% of SDH systems, 27% of WDM systems, and 10% of DIC systems are in condition C4.

All PLC systems, about 60% of WDM systems, 25% of SDH systems, 12% of PDH systems, and 9% of PTP systems are in condition C3.

The remaining systems are in condition C1 or C2.

3.5 Asset Criticality

The communication system provides services for power system protection, SCADA, Control, and telephony. Under electricity network fault conditions, unavailable communication systems will affect the duration of outage, damage to equipment, 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 – potentially leading to equipment or other damages and/or impacting the electricity market prices.
- Inability of SCADA master to get or send information to field devices. This results in electricity network control reverting to manual operations and therefore an increase in the number of resources to manage the electricity network. The market prices may increase because longer outage duration constrains the network.
- Failure of maintenance crew to communicate with CEOT resulting in accidental switching and delayed or suspended maintenance activities.

The economic impact consists of the summation of the following:

- Bushfire start impact.
- Health and safety impact.
- Value of unserved energy.

3.6 Asset Performance

Apart from optical fibre cables and antennas, most of the systems have electronic components which by nature and complexity do not exhibit a point at which the failure rate begins to increase. As long as the operating environment conforms to the recommended specifications most communication systems will experience random failure characteristics. However, when the environment does not meet specifications as recommended, systems get exposed to high/low temperatures, moisture, vermin, and mechanical stress.

Communication Cables and Antennas

The main causes of failure of OPGW are lightning strikes and tower collapses. Both occurrences are random and rarely occur. ADSS cables main cause of failure is cable breaks due to cars and trucks knocking down poles or pulling down cables that run across roads. Underground optical fibre cable is prone to damage during excavations.

Antennas systems 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 is 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.

4 OTHER ISSUES

Issues and drivers that influence the decisions around technology changes and/or asset replacement are multi-fold. There are specific drivers for each technology category, and these are described in general terms in the following sections.

4.1 Regulatory Requirements

The National Electricity Rules (NER) outlines performance and other technical requirements for the electricity transmission network. Requirements that directly impact communications systems include:

- ***Performance*** *– Fault clearance times as outlined in rule S5.1a.8 for protection systems at specified electricity transmission network voltages. These specified times are end-to-end operation times which include communications operation and signal transmission time.*
- ***Redundancy*** *– specifies that the system must operate within the performance constraints with any single communications element out of service (S5.1.9d)*
- ***Availability*** *– Electrical protection systems, which includes communications signalling, always available, apart from a maximum period of 8 hours outlined in S5.1.2.1d*
- ***Availability*** *– A back-up telephone facility independent of commercial telephone service providers (S5.2.6.2).*

The Electricity Safety Act (section 98(a)) requires AusNet Services to:

> *design, construct, operate, maintain and decommission its supply network to minimise as far as is practicable the hazards and risks to the safety of any person arising from the supply network; taking into consideration:*
>
> *a) severity of the hazard or risk in question; and*
>
> *b) state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and*
>
> *c) availability and suitability of ways to remove or mitigate the hazard or risk; and*
>
> *d) cost of removing or mitigating the hazard or risk".*

Communication systems contribute to meeting the above requirements by providing services for protection schemes, SCADA, voice communication, site access security and video monitoring.

AusNet Services adopts the ISO 27001 framework for security management and governance, and aligns people, process, and technology to this international standard.

4.2 Technological Issues

4.2.1 Supportability

Due to the rapid advancements in communication technologies, modern equivalents are being introduced in an increasingly shorter timeframe. The knock-on effect is that vendors declare end-of-support for older technologies and spare parts become scarce.

Inadequate support negatively impacts the availability of systems to a point where applications that utilise these services are impacted.

4.2.2 Legacy Systems

The communications network is made up of devices from multiple vendors and interoperability challenges arise between different vendors due to the difference in the pace of evolution of technologies by the various vendors. As a result, a change from one vendor in the part of the network may limit the interoperability of the overall network forcing a technology refresh.

AusNet Services is currently analysing suitable IEC 61850 practices and standards for substation automation. In its current format, the communication system does not meet the requirements of implementing IEC 61850.

TDM based telephony systems and analogue signal based 'Plain Old Telephone Services' (POTS) are becoming increasingly difficult to maintain as these technologies are migrating to packet-based VoIP equivalents. Office locations and operational sites are being impacted by the reduced maintenance support and require migration of existing analogue telecommunication services to digital NBN based equivalents.

4.3 Information Cyber Security

Utilities are faced with the challenge of building computer networks that withstand cyber-attacks. These attacks can impact the integrity of the electricity network and/or compromise the confidentiality of AusNet Services customer information.

AusNet Services identifies the North American Electric Reliability Corporation – Critical Infrastructure Protection (NERC-CIP) framework as current industry best practice and a prudent basis for cyber security enhancement. Alignment with the NERC CIP framework ensures compliance with ISO 27019[1] based on ISO/IEC 27002[2], and IEC 62443[3].

[1] ISO 27019 Information security management guidelines

[2] ISO/IEC 27002 Process control systems specific to the energy industry

[3] IEC 62443 Industrial communication networks - Network and system security

5 RISK AND OPTIONS ANALYSIS

5.1 Overview

AusNet Services uses both qualitative and quantitative risk evaluation methods. Quantitative analysis is the preferred option but is limited by the availability of appropriate metrics which include failure data and consequence measurements.

The risk evaluation of communication assets included both qualitative and quantitative assessments. PDH, SDH, WDM, and PTP radio assets were analysed using the quantitative method with the results of the assessment provided in the document "***AMS CIR – Risk Assessment of Communication Assets V01.02***" and summarised below.

All the other assets which include telephony, DC supply systems, DIC systems, optical fibre cables, and antennas were analysed using the qualitative method.

5.1.1 Quantitative Assessment

Risk level is determined by the probability of failure and consequence resulting from the failure. Probability of failure is determined from the failure rates of the assets and the consequence of failure is inability to provide electricity to customers.

The results for the quantitative analysis ranks assets on a scale R1 to R5 in which R1 is low risk and R5 very high risk. The Risk Bands and Condition Scores are correlated in a matrix as shown in Table 13 to provide guidance on communication asset maintenance.

Table 13: Asset Management Guidelines

Risk Band	Condition				
	C1	C2	C3	C4	C5
R5	Design Investigation	Inspection Functional Tests	Schedule replacement	Schedule replacement	Schedule replacement
R4	Design Investigation	Inspection Functional Tests	Schedule replacement	Schedule replacement	Schedule replacement
R3	Design Investigation	Inspection Functional Tests	Inspection Functional Tests	Schedule replacement	Schedule replacement
R2	Inspection	Inspection	Inspection	Inspection Functional Tests	Inspection Functional Tests
R1	Inspection	Inspection	Inspection	Inspection	Inspection

The percentage of assets assessed in each category is shown in Table 14.

Table 14: Percentage of Assets – Condition and Risk Band

Risk Band	Percentage of Assets					
	C1	C2	C3	C4	C5	Total
R5				1.3%		1.3%
R4				4.4%		4.4%
R3				9.0%		9.0%
R2			0.3%	34.5%		34.8%
R1	0.3%	39.7%	10.5%			50.5%
Total	0.3%	39.7%	10.8%	49.2%		*100%*

According to the results shown in Table 14, 14.7% of the assets assessed should be replaced. The breakdown of the 14.7% of the communication assets to be replaced are shown in Table 15.

Table 15: Quantity of Schedule Replacement

Asset Class	Quantity
PDH	128
SDH	88
WDM	4
PTP	4

5.1.2 Qualitative Assessment

Telephony systems, DC supply systems, DICs, optical fibre, and antennas have not undergone a failure mode effects analysis (FMEA) and therefore have been analysed using the qualitative method.

The methodology uses the consequence table and risk level matrix in RM 10-01-1[4].

Table 16: AusNet Services Risk Level Matrix

		Consequence				
		1	**2**	**3**	**4**	**5**
Likelihood	**Almost Certain**	C	C	B	A	A
	Likely	D	C	B	B	A
	Possible	E	D	C	B	A
	Unlikely	E	D	D	C	B
	Rare	E	E	D	C	C

C5 assets have a likelihood rating of Almost Certain and Likely. The consequences of failure include customer supply and, in some instances, safety. From the corporate risk table, the consequence levels are 4 and 5.

The number of assets to be replaced was determined as shown in Table 17.

Table 17: Quantity of Asset Replacement

Asset Class	Quantity
Telephony systems	36
DC systems	18

[4] RM 10-01-1 Corporate Risk Assessment Processes & Criteria

5.2 Replacement Programs

5.2.1 Network Technologies

Table 15 shows a summary of network technology assets to be replaced. It is expected that the replacements will introduce new technologies, with a possible change to interfaces and protocols.

As a network, which includes loops and connections at endpoints, introducing a new technology for a high-risk asset will impact adjacent assets. Replacement of a high-risk asset in a loop means all assets in the loop should be replaced. Likewise, replacing a high-risk terminal asset means that all systems connected to the terminal equipment should be replaced.

SDH and WDM assets are normally connected in loops and therefore some low risk assets in the loops will be replaced. Replacing PDH assets will impact systems which are connected to the affected asset even though they are low risk assets. Assets connected to the PDH include telephony systems, DIC systems and TPS.

Taking these factors into consideration, the adjusted quantities of systems to be replaced are shown in Table 18. The DIC systems and TPS are a result of the new PDH systems.

Table 18: Program Scope

Asset Class	Final Quantity
PDH	240
SDH	145
TPS	210
WDM	32
DIC	125

The introduction of new technologies is impacted by the bearer network. Latrobe Valley and the South West regions will require a reassessment of the bearer network to accommodate the new technologies. It is proposed to initiate three programs under network technologies as follows:

- Metro and North East
- Latrobe Valley
- South West

5.2.2 PTP Radio

Table 15 shows four PTP radio assets to be replaced through the risk assessment process. However, because radio links form part of the SDH loops, an additional six links will be impacted because of replacements proposed under the Network Technologies program in the Metro and North East regions. This increases the PTP radio program to 10 links

5.2.3 Others

Telephony

The telephony assets will be replacement at 36 transmission network sites.

DC Supply Systems

Proposed to replace DC supply systems at 18 terminal station.

5.3 Options

Each program has been analysed with replacement on failure as the base case (Business-As-Usual). The other options explore varying the timing of the replacements.

In the business-as-usual option, assets are maintained using existing spares and resources. When spares and/or resources become scarce, alternative similar equipment is identified to replace the failed asset:

- Drawdown on existing spares when failures occur
- Replace failed equipment with similar equipment when spares/resources are depleted

Evaluation

Long duration failures but eventually all obsolete equipment is replaced:

- Gradual reduction in manufacturer support capabilities
- Increase in reverse engineering to maintain assets
- Increase in maintenance time searching for replacement asset
- Repeat system outages
- Replace asset with alternative when spares and other resources are not available

Result

Eventually all obsolete or degraded assets are replaced. Maintenance costs are high because unplanned mobilisation costs more than planned mobilisation, failures impact EHV line availability and customers experience supply outages and/or increased electricity charges:

- Increased operational and maintenance costs for in-service equipment but reductions as old assets are replaced
- High capital expenditures because of high unplanned replacement costs. Typically, unplanned replacement attracts between 10% - 100% premium of a planned cost
- Increased cost of replacement equipment – equipment is produced on special order (not a regular manufactured product)
- Longer lead time for equipment supply which translates to longer equipment outage time and therefore longer periods of network constraint

An economic analysis of each program was performed using Net Present Value (NPV) model as summarised below.

5.3.1 Network Technologies (Metro and North East)

An economic analysis of the options was performed, and the results are shown in Figure 3. The planned replacement (option 2) has the lowest total PV cost.

[C-I-C]

Figure 3: NPV – Metro and North East

5.3.2 Latrobe Valley

Results of an economic analysis of the options is shown in Figure 4. The planned replacement (option 4) has the lowest total PV cost.

[C-I-C]

Figure 4: NPV – Latrobe Valley

5.3.3 South West

An economic analysis of the options was performed, and the results shown in Figure 5. The planned replacement (option 4) has the lowest total PV cost.

[C-I-C]

Figure 5: NPV – South West

5.3.4 PTP Radio Replacement

An economic analysis shows that the planned replacement Option 2 has the lowest PV cost (Figure 6).

[C-I-C]

Figure 6: NPV – PTP Radio

5.3.5 Telephony

The results of the economic analysis using the NPV model are shown Figure 7. Option 2 as the least cost option.

[C-I-C]

Figure 7 NPV - Telephony

5.3.6 DC Supply Systems

The results of the economic analysis using the NPV model are shown in Figure 8 Option 2 is the least cost option.

[C-I-C]

Figure 8 NPV – DC Supply Systems

6 STRATEGIES

The proposed strategies for the communications systems are described in the following sections.

6.1 Bearer Strategy

- A minimum of two independent communications bearers to each EHV terminal station
- When selecting a new installation or replacing an existing bearer, the priority for options to be considered in the economic analysis will be as follows:

Main route:

–	OPGW	AusNet Services owned fibre
–	Point-to-Point	AusNet Services owned digital radio
–	Underground	AusNet Services owned fibre
–	Power Line Carrier	AusNet Services owned

Second route:

–	OPGW	AusNet Services owned fibre
–	Point-to-Point	AusNet Services owned digital radio
–	Underground	AusNet Services owned fibre
–	ADSS	AusNet Services owned fibre
–	Optical Fibre	Third Party
–	Power Line Carrier	AusNet Services owned

- Install OPGW in conjunction with planned EHV ground wire replacement programs
- Install OPGW fibre on new EHV line construction or refurbishments
- Replace end-of-life Point-to-Point radio links to modern equivalents
- Identify ongoing suitability of digital Power Line Carrier technology when other alternatives cannot be justified
- Establish condition monitoring for optical fibre cables

6.2 Network Technologies Strategy

- Identify and standardise suitable next generation WDM, SDH, PDH, and TPS systems
- Replace end-of-life SDH equipment with next generation equivalent
- Replace end-of-life PDH equipment with next generation equivalent
- Replace end-of-life WDM equipment with next generation equivalent
- Replace end-of-life Routers, Switches and Serial Servers with next generation equivalents
- Replace end-of-life Tele-protection equipment with new equivalent technology
- Update the communication Design Standard to support IEC 61850 applications
- Migrate 3G wireless technology to new equivalent wireless service

6.3 Telephony Strategy

- Identify opportunities for system consolidation considering business wide requirements
- Replace end-of-life PABX with new equivalents
- Replace end-of-life mobile radio handsets to new equivalents

6.4 Operational Support Systems Strategy

- Replace end-of-life network management systems hardware and software
- Develop a centralised network management system for both the OMN and ODN network devices

6.5 Supporting Infrastructure Strategy

- Replace antenna systems when necessary
- Replace C5 and C4 batteries
- Replace air conditioning systems based on site requirements

6.6 Security Strategy

- Implement user access control system – for users and devices
- Upgrade SIEM to latest capability
- Continue to improve the centralised Authentication, Authorisation and Audit for ICS environment

APPENDIX A SCHEDULE OF REVISIONS

Issue	Description
0.1	Initial 2011/2012 updates
0.9	ICT Review
1.0	Final for NSD editorial review
1.1	Final - Modified as per review comments
1.2	Initial 2015 updates incorporating latest template
1.3	Draft version for comment
9	Final – Modified as per review comments

APPENDIX B 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
CEOT	Customer and Energy Operations Team
CWDM	Coarse Wave Division Multiplexing
DIC	Digital Interface Cubicle
DWDM	Dense Wave Division Multiplexing
EHV	Extra High Voltage
EMI	Electromagnetic Interference
HMX	Kilo-Mux
HV	High Voltage
ICT	Information Communication Technology
IED	Intelligent Electronic Device
IP	Internet Protocol
IPVPN	Internet Protocol Virtual Private Network
IS	Information Security
LDT	Line Despatch Terminal
MIP	Market Impact Parameter
MPLS	Multi-Protocol Label Switching
NBN	National Broadband Network
NOC	Network Operations Centre
ODN	Operational Data Network
OFC	Optical Fibre Cable
OMN	Operational Management Network
OPGW	Optical Fibre in Ground Wire
OSS	Operational Support Systems
OTN	Operational Telephony Network
PDH	Plesiochronous Digital Hierarchy
POTS	Plain Old Telephone Service
PSTN	Public Switching Telephony Network
PTP	Point-to-Point
QoS	Quality of Service

Abbreviation	Description
EDAMS	Electricity Distribution Metering Asset Management Strategy
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SIEM	Security Information and Event Managers
TDM	Time Division Multiplexing
TMR	Trunk Mobile Radio
TPS	Tele-protection System
TS	Terminal Station
U/G	Under Ground
VCR	Value of Customer Reliability
VFRB	Very Fast Runback
VOIP	Voice Over Internet Protocol
VRLA	Valve Regulated Lead Acid
VSWR	Voltage Standing Wave Ratio
ZSS	Zone Sub Station