ActewAGL Distribution, Telecommunications Strategy

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Contents

1 Background

The existing ActewAGL Distribution SCADA telecommunications network is a mix of UHF digital radios (DDRN) and pilot wires, with some small scale use of optical fibre and microwave links. The network is extremely limited in capacity and does not provide adequate and timely real time SCADA information for effective control room operations, with some analogue and digital changes taking several minutes to be reported. The performance constraints of the network present a roadblock to realising the benefits of the SCADA system and this will only become more apparent with the implementation of the ADMS, where real time data is critical to correctly calculating the network state, load flows and correctly reporting network outages.

In the last few years in an attempt to overcome these shortcomings in the DDRN, the SCADA communications network has been augmented with some higher capacity IP links to some zone and distribution substations. These higher capacity IP links have been implemented using optical fibre and microwave links to specific substations. While this has satisfied individual project needs, the overall communications network requirements have not been thoroughly considered and documented. Going forward, a more structured network architecture will be required to maximise the benefits of investments and ensuring we meet the requirements of SCADA, protection and other business needs of the Networks Divisions.

In addition to SCADA communications, the other critical application for communications is with ActewAGL Distribution's network protection. Increasingly some aspects of the protection systems will require communications to overcome protection performance and grading issues. In particular, the performance of the existing 132kV network protection falls short of technical compliance with the current National Electricity Rules. These performance shortcomings are considered acceptable due to 'grandfathering' provisions within the Rules, but as network upgrades and augmentations occur the network protection will need to be brought into compliance with current standards. Augmentations such as connecting generators to the network[1] or when the 132kV network is upgraded or modified[2] are triggers for protection upgrades. Required protection upgrades may include the implementation of intertripping and line differential protection schemes and these are dependent on reliable and secure communications. In the future, the emergence of IEC 61850 as the industry standard substation automation and protection communications standard will require a very high level of reliability in the communications network.

For mobile voice communications, ActewAGL Distribution currently employs a TMR radio system operating in the 400MHz UHF band and a VHF radio network operating at 70Mhz. The VHF radio equipment has reached the end of its useful life and it is proposed to upgrade the remaining VHF base station at Mt Tennent to a TMR base. This will rationalise the deployment of bases and mobile radios to the TMR radio system.

[1] A connection agreement for the Royalla FRV 20MW solar farm has been accepted by ActewAGL Distribution and is expected to be completed by end 2013.

[2] With the completion of the Williamsdale supply point ActewAGL is now classified as a TNSP, ActewAGL Distribution's re-classification as a TNSP or the need for new work to meet TNSP obligations would most likely trigger the requirement to comply with the new performance standards.

This strategy proposes a multi service fibre optic and microwave MPLS network covering the main control centre at Fyshwick, the future DRF facility at Civic Zone substation and connecting to all zone substations. The distribution network will be serviced by a mix of fibre optic and an upgraded DDRN. The communication network will also support requirements for advanced metering and future network automation requirements. The multi service network will provide individual virtual private networks for different services such as protection, SCADA, advanced metering and corporate services. This strategy aligns with the ICT strategy by ensuring Operational Technology (OT) systems are independent of, and segmented from, corporate ICT services.

2 Business Requirements

The telecommunications business requirements need to cater for the existing and future needs of electrical network operations and corporate requirements for operating the electrical network. An overview of these business requirements are as follows,

Current usage

1. Zone substation protection signalling, including communications for intertripping and line differential protection,
2. SCADA communications to zone substations, fault passage indicators, reclosers, switches and distribution substations,
3. Security video and remote access management,
4. Substation VoIP telephone,
5. Corporate data services,

Prospective usage

6. Advanced metering infrastructure (AMI) communications,
7. Inter station protection and control schemes,
8. Intra station protection schemes utilising IEC61850 and goose messaging,
9. Substation engineering access, for example remote access to protection relay fault records,
10. Mobility communication to vehicles & deployed mobile tablets/computers,
11. Network video, for example infrared cameras for switchyard fault detection,
12. Monitoring and management of the communication network (MPLS devices),
13. Distribution Feeder Automation (DFA),
14. Power Quality Monitoring (PQM).

2.1 Current situation and Options

2.1.1 132kV line protection

Currently ActewAGL Distribution uses Distance protection on most 132kV transmission lines. Distance protection utilizes voltage and current inputs and the line impedance in an algorithm that looks at the positive sequence impedance for various types of faults. Zone 1 protection operates instantaneously for 80% of the line section, whereas zone 2 and zone 3 backs-up Zone 1 and provides protection for 100% of faults. Zones 2 and 3 operate at 400ms and 800ms respectively. Distance protection does not currently utilise any communications between the protection relays at either end of the circuit. Faults in the first and last 20% of distance protected circuits (40% of the circuit) will be cleared in 500 ms (Z2 time plus 100 ms CB current breaking time)

Distance protection can be enhanced to provide unit protection with acceleration or intertripping communications between the protection relays at each end of the circuit. It allows faster tripping for a larger range of faults within the required maximum 120ms tripping time under the NER. For these reasons it is recommended that ActewAGL Distribution enhances the distance protection with intertripping as OPGW is rolled out under this communications strategy.

Line differential protection monitors the difference of current inputs from current transformers at either end of a cable section. For normal conditions, the protection does not see any difference in current as current entering equals current leaving the cable section indicating that the cable section is healthy. Line differential protection is required for underground cables or extremely short 132 kV overhead lines.

The preferred options of distance protection with intertripping and line differential protection, will achieve NER compliant clearance times for the entirety of each circuit.

Options (for consideration in individual business cases)

1. **Do nothing** – continue to use line distance without signal cooperation

   Advantages

   - simple well proven scheme that does not require communications

   Disadvantages

   - longer tripping time for zone 2 and 3 protection that may not meet requirements under the NER.

2. **Distance protection with intertripping**

   Preferred option for longer 132 kV overhead lines.

   Advantages

   - faster tripping time that will meet the requirements under the NER
   - can be deployed as part of relays renewal program once OPGW is available
   - minimal incremental cost once OPGW is available
   - will still operate as normal distance protection if communications fails

   Disadvantages

   - requires communications for intertripping to operate

3. **Line differential protection**

   Preferred (required) option for underground cables or extremely short 132 kV overhead lines.

   Advantages

   - deploy differential relays as part of the relay renewal program
   - minimal incremental cost once OPGW is available

   Disadvantages

   - Will not operate if communications fails (reliant on backup overcurrent)
   - requires OPGW with secure backup, higher cost

An allowance for sufficient capacity on the OPGW between zone substations is included in the OPGW fibre count calculation in section 4.1.2.

2.1.2 Future 132kV network synchro-phasors (zone substations)

Phasor measurement units (PMUs) are devices that measure phase angles in the network and enable synchronisation checking prior to closing circuit breakers. They also facilitate calculation of network load flow in the ADMS and this can improve network performance and reliability. Currently, ActewAGL Distribution does not have phasor measurements in the 132kV network and does not have check synchronisation capability when closing open points in either the 132kV network or 11 kV network. With the introduction of the second bulk supply point from Transgrid at Williamsdale, there can be a large phase angle difference across open points, which may be unsafe to close or could result in large circulating currents under certain conditions.

The installation of PMUs (Syncro-phasors) at strategic points in the 132kV network will be proposed under a separate business case. Using data from PMUs, the ADMS can calculate necessary phase angle differences across open points and load flows from state estimation to enable safer and more optimal operation and planning of the electrical network.

PMUs (Syncro-phasors) will require the exchange of time synchronisation information using C37.118-2005 protocol and this requires fibre optic circuits between zone substations where the Syncro-phasors will be installed. Capacity on the OPGW between zone substations is included in the OPGW fibre count calculation in section 4.1.2.

2.1.3 SCADA communications (zone substations)

The existing SCADA communications network connects the SCADA master station at Fyshwick and disaster recovery facility (DRF) at Greenway to zone substation SCADA RTUs and SCADA enabled distribution assets. The DRF will move to Civic ZS in 2015 with the implementation of the new ADMS master station. Whilst the primary purpose of the SCADA communications network is to provide SCADA communications for network monitoring and control, the system needs to also support other zone substation communications requirements for business and engineering functions.

An analysis of the current ZS communications system undertaken by Jacobs Australia highlighted the following capability shortfalls:

- The current Digital Data Radio Network (DDRN) owned and operated by ActewAGL Distribution has limited bandwidth capacity to cope with additional communications requirements;
- The current DDRN is comprised of multiple point-to-point links with multiple single points of failure. This limits the reliability/availability of the system;
- The current SCADA communications system is not encrypted, which increases its vulnerability to outside interference;
- A number of operational problems have been highlighted by System Control such as control commands timing out due to congested communications channels, inadequate sequence of events data (particularly those time-stamped on receipt at the master station), inability to verify control commands and unacceptable system response times (some indications taking several minutes to be received); and
- Electricity network monitoring and control data traffic is not adequately segregated from corporate traffic and this poses a cyber-security and data integrity risk.

Jacobs Australia was also engaged to carry out the required analysis into various communications options capable of meeting current and future ZS communication needs. High level capabilities required by current and future ZS communication needs are identified as:

- Electricity network monitoring and control (SCADA);
- Remote engineering access to ZS RTUs;
- Remote engineering access to ZS protection relays;
- ZS Closed Circuit Television (CCTV) monitoring and control;
- ZS electronic security access control and intruder detection; and
- ZS corporate LAN/WAN access.

Bandwidth requirements for each capability have been calculated using a Monte-Carlo 3 point estimate model. Accounting for anticipated future expansion in the ActewAGL Distribution electricity network, as well as expected growth in capability, total bandwidth requirements across all ZS has been estimated to be:

- Under normal operating conditions the planned bandwidth requirement is estimated to be 28 Mbps;
- Under high activity operating conditions, with a 90% confidence level, the bandwidth requirement is estimated to be 76 Mbps; and
- Under worst case conditions the estimated bandwidth requirement is 90 Mbps.

In meeting the capabilities, needs and bandwidth requirements a number of communications options are considered below. These options have each been assessed against estimated bandwidth requirements as well as a number of other performance criteria.

A list of existing and proposed (near future) optical fibre connections is at Appendix C.

Options

1. **Do nothing** – continue to use DDRN as the main SCADA communications medium.

   Advantages

   - NIL cost

   Disadvantages

   - Limited bandwidth capacity
   - Poor reliability/availability
   - Inadequate sequence of events data, inability to verify control commands and unacceptable system response times (some indications taking several minutes to be received)
   - Unencrypted data posing cyber security and data integrity risks

2. **Use ACT Intra Government Communications Network (ICON) or TransACT**

   Disadvantages / Limitations

   - Use of the ICON network by ActewAGL Distribution is bound by the Commonwealth of Australia, Telecommunications Act 1997 and a 2013 Determination. Under the determination, the Commonwealth have made designated parts of the ICON fibre network available to ActewAGL Distribution for critical utility services. The parts of the ICON network that are available are classified as category A ICON Communications Infrastructure as listed in appendix B

- The category A ICON infrastructure has been reviewed and is not available at zone substation locations
- Use of Transact fibre will be subject to commercial agreements between ActewAGL Distribution and Transact

Use of Transact/ICON fibre would require special considerations when bringing into substations, particularly in relation to mutual access requirements by the service providers and contractors. Prospective usage is limited to:

- Use of the existing Transact fibre between Fyshwick and Civic Zone substation
- Use of the TransACT fibre between Fyshwick and distribution sub TBA (TransACT House)
- Use of ICON fibres where Commonwealth entities make the request to ICON (as in the case of distribution sub 9555)
- Possible use of Transact fibre in the distribution network for the WAN edge. This shall be considered in business cases for any rollout of communications in the 11kV distribution network.

3. **Expand existing microwave network**

Advantages

- Faster roll out compared to fibre

Disadvantages

- Analysis of the microwave option has highlighted a number of single points of failure
- Would not meet other business requirements such as protection
- Would not have sufficient capacity for future business requirements such as AMI
- Microwave radio performance is affected by changing environmental conditions, less reliable than fibre
- Higher OPEX (compared to fibre) due to tower and equipment maintenance and site lease costs
- Shorter asset lifespan (15 years) compared to fibre (40+ years)

4. **Redundant fibre optic utilising existing microwave to provide redundancy**

<u>Preferred Option.</u>

Advantages

- Aligns with the preferred option for protection and can utilise shared OPGW bearers between substations
- Redundancy unaffected by single points of failure
- Utilises existing microwave infrastructure to reduce total CAPEX (compared to a fully redundant fibre network)
- Higher capacity (1 Gigabit minimum) with room to grow for future business requirements
- Less equipment and complexity than microwave, leading to lower OPEX and renewal costs
- More reliable, unaffected by changing environmental conditions

Disadvantages

- Needs to be rolled out as a meshed network requiring staged investment covering a number of stations. (We are proposing 4 investment stages in section 0)

5. **Fully Redundant fibre optic network**

Advantages

- Would provide extremely high reliability with no loss of network speed under various failure scenarios once fully deployed

Disadvantages

- Higher CAPEX investment required
- Will leave stranded assets in the microwave network

Overall, the redundant fibre optic and microwave network solution presents the optimal approach balancing cost, installation timeframe, performance and reliability. It also represents better value for money over the life cycle of the assets, with fibre lasting over 40 years. On this basis, and taking into account the additional considerations discussed above, option 4 for a redundant fibre optic utilising existing microwave to provide redundancy is recommended.

2.1.4 AEMO ICCP communications

Under the NER, AEMO requires inter control centre protocol (ICCP) SCADA information from the ActewAGL Distribution 132kV transmission network and embedded generators. Currently AEMO is provided with data through a copper line DSL service to Transgrid's Canberra Substation. This does not currently meet AEMO's redundancy requirements.

1. **Do nothing –** continue to use the DSL service to Transgrid's Canberra Zone Substation

   Disadvantages

   - Does not comply with AEMO requirements

2. **Use fibre into Transgrid's Canberra and Williamsdale substations**

   Advantages

   - Share infrastructure (and costs) with the preferred SCADA communications option above
   - Meets AEMO redundancy and availability requirements

2.2 Risks and Controls

If we do not proceed with this strategy the business will be exposed to the following risks:

1. Cyber security risks. Currently IP connections to substations are provisioned over the corporate network with firewalls configured at both the substation and SCADA master station endpoints. This is a complex and costly configuration both in terms of CAPEX investments in multiple firewalls and also the OPEX required to maintain configurations. Network virtualisation, network segregation and data encryption offered by the MPLS solution under this strategy, are key mitigations for these cyber vulnerabilities[3] and will reduce lifecycle costs.
2. Radio system cyber security risks. The existing radio network design exposes radio repeaters and substation SCADA RTUs to cyber intrusion and denial of service attacks. The risks to ActewAGL Distribution are similar to those from the Maroochy Water Services SCADA Cyber Security attack[4] in the year 2000, where a hacker operated radio

[3] Mitigations for Security Vulnerabilities Found in Control System Networks, The Instrumentation, Systems and Automation Society.

[4] Malicious Control System Cyber Security Attack Case Study–Maroochy Water Services, Abrams and Weiss

controlled sewage equipment. Migrating the zone substations to MPLS and upgrading the DDRN (section 3.4) will mitigate these risks.

3. Inefficient field operations due to failure of SCADA control signals (time out), slow SCADA data reporting and non-redundant SCADA communication failures. Currently some control commands routinely require multiple attempts to achieve execution and analogue/digital changes take several minutes to be reported.
4. Lengthy SCADA outages due to non-redundant communication failures (three outages occurred over 2011-2013). The proposed communications strategy and availability standards will provide the necessary communication bandwidth and redundancy for more effective operations.
5. Disaster recovery operational risks. The current IP connections into substations require manual reconfiguration to enable network operations to function from the DRF. Furthermore there is insufficient redundancy to accommodate routine maintenance of the communications infrastructure without loss of Network Operational control concurrently at both main and back up control rooms. The proposed WAN backbone will provide the required N-1 redundant communications into the main and DR control centres and all zone substations.
6. Not meeting obligations to AEMO under the NER. AEMO requires[5] that NSPs provide ICCP SCADA data within the following standards: main system status indications be received within 8 seconds and analogue values be received within 14 seconds. These requirements are for the end-to-end latency from the primary plant operation to the indications and logging in the SCADA master station. AEMO also requires redundancy in the ICCP communications paths. Currently ActewAGL Distribution does not meet these requirements due to bandwidth limitations in the DDRN and lack of backup communication paths to Transgrid and AEMO. The proposed high capacity WAN backbone is designed to meet these requirements.
7. Not realising the full benefits of the ADMS. The ADMS will require timely real time data to correctly calculate the network state, load flows and correctly report network outages. It is also capable of advanced distribution automation schemes. The current limitations in communication bandwidth and redundancy will impact the timeliness of SCADA data reporting from field devices therefore the operation of the ADMS.
8. Risks to advanced metering infrastructure (AMI) rollouts. A high performance, reliable and secure communication network is one of the fundamental building blocks to the introduction of AMI.
9. Risks to customer connection agreements and future embedded generation projects. Communications is a necessary requirement for HV customer connections and large embedded generation installations.

3 Strategic Vision

The strategic vision for the ActewAGL Distribution communication network is to create a converged communication network to deliver multiple services required for the existing and future requirements of the electrical network as outlined in Section 2.

To deliver these requirements a structured network is proposed with the following tiers:

- Wide Area Network (WAN)
- WAN edge
- Neighbourhood Area Network (NAN)
- Digital Data Radio Network (DDRN)

[5] As defined in AEMO's draft standard for power system data communications

3.1 Wide Area Network (WAN) backbone

It is proposed to create a WAN backbone with communications to:

- the main and backup control centres at Fyshwick and Civic;
- all zone substations; and
- edge WAN connection points

The WAN backbone will use fibre optic and microwave links employed in an MPLS network. The network topology shall be meshed to ensure there is at least N-1 redundancy to each control centre and zone substation so there are no single points of failure.

ActewAGL Distribution has an associated strategy and augmentation plan to roll out OPGW on its 132kV network. The WAN backbone will utilise this fibre in the MPLS network as outlined in Section 5.

As a multi-service network is proposed, with some high bandwidth service requirements such as video and advanced metering backhaul, the backbone should be implemented with minimum 1 gigabit Ethernet links between control centres and zone substations.

3.2 WAN edge

WAN edge tier provides communication requirements for:

- distribution substations;
- HV customer and generator network connections;
- NAN connection points, including mesh radio base stations or powerline communications (PLC) connection points

The WAN edge will predominantly use fibre optic cores configured in an Ethernet star topology. There is no baseline requirement for redundancy in the WAN edge network and any redundancy requirements may be considered for critical sites on a case-by-case basis. Where redundancy is required, Ethernet ring topologies or dual homed topologies may be used.

3.3 Neighbourhood Area Network (NAN)

Neighbourhood Area Network (NAN) providing communication requirements for:

- LV customer advanced metering; and
- LV distribution network automation.

The Neighbourhood Area Network (NAN) is an emerging requirement with the rollout of advanced metering infrastructure (AMI). The network may utilise different technologies, with RF mesh and PLC from the WAN edge connection points to endpoint devices in the LV network.

3.4 Digital Data Radio Network (DDRN)

The current DDRN is the main communications medium for zone substations, some distribution substations, field reclosers and switches. The DDRN uses 12.5 kHz channels in UHF licensed spectrum in the 400 MHz band. The 400 MHz base stations serve a notional 30km radius area.

The 400 MHz radios currently used in the ActewAGL Distribution SCADA network are Trio E series. These radios operate in point to multipoint network and have a transport data rate of 9.6 kbps shared between all remotes. As noted above the performance of the current DDRN communication is becoming inadequate for effectively managing the electrical network. The available bandwidth and performance is not sufficient to meet requirements for zone substation SCADA and going forward the DDRN should only be used for SCADA in the distribution network.

In future DDRN will provide communication requirements for:

- field reclosers and switches;
- distribution substation communications where a fibre WAN edge connection is unviable.

Even for the proposed usage within the distribution network, the current DDRN performance will not be sufficient for automated schemes within the centralised ADMS. Progressively upgrading the DDRN to a higher speed IP based solution is proposed to enable these advanced distribution automation schemes and realise the full benefits of the ADMS.

The strategy is to upgrade the DDRN radios to higher speed IP solution, either Trio Q series or 4RF. These radios offer data rates up to 56 kbps and will allow end devices to report by exception to minimise scanning latency and will enable advanced automation. IP radios will also have additional benefits in data encryption and enabling remote management of field devices.

For existing network assets, upgrading of the DDRN network endpoints will occur during the normal communication asset renewal cycle; for new assets IP radio solutions will be deployed during construction.

3.5 Voice Radio and Mobility

A mobility solution is currently under consideration as part of the OSR program. This may be deployed on tablets and Toughbook personal computers to provide access to Cityworks and dispatch systems used by the control room. Due to the high bandwidth requirements, commercial carrier networks, 3G or 4G, are the only viable options.

For Voice Radio, ActewAGL Distribution is currently using two technologies, a VHF system and a UHF system. The VHF equipment has reached the end of life, and the strategy going forward is to replace the existing VHF equipment at Mt Tennent with UHF TMR, equipment and thereby rationalise all mobile and base station radio systems to the one UHF, TMR technology.

4 Telecommunications Bearers

Telecommunications Bearers are the physical medium used for transportation of signals between sites.

The following bearer types are currently in use in the ActewAGL Distribution network:

- Optical Fibre
- Microwave Radio
- UHF Digital Radio (in the DDRN outlined above)
- Metallic pilots (not to be considered for future requirements)

4.1 Optical fibre

Optical fibre cabling is widely used in the power industry, with the capability of supporting high transmission bandwidth on individual fibre pairs (2 x fibres for transmit and receive).

The benefits of fibre cabling include:

- large capacity medium compared to other bearer types such as radio, power line carrier and metallic pilot cables;
- reliable carriage that achieves zero transmission error and performance that is unaffected by changing environmental conditions;
- can be run with electrical transmission and distribution lines with a small incremental cost;
- low environmental impact.

4.1.1 Optical fibre deployment option considerations

The optical fibre deployment method used for WAN backbone and WAN edge networks, shall be considered in the order of preference outlined in the following table.

Optical fibre deployment method	Reliability	Application
OPGW on overhead transmission lines	Very High	Protection signalling - Preferred option WAN backbone – Preferred option WAN edge – Not to be used
Underground fibre in transmission communication ducts	Very High	Protection signalling - Preferred option WAN backbone – Preferred option WAN edge – transmission communication ducts may be used
Underground fibre in distribution communication ducts	Medium High	Protection signalling – Not Applicable WAN backbone – may be used WAN edge – preferred option
ICON or TransACT	Medium	Protection signalling – Not Applicable WAN backbone – may be used WAN edge – may be used
ADSS on transmission or distribution poles, below HV conductors	Medium	Protection signalling – Not Applicable WAN backbone – may be used WAN edge – may be used
ADSS on LV poles, on LV cross arm or below LV conductors	Low	Protection signalling – Not Applicable WAN backbone – Not to be used WAN edge – may be used as the least preferred option

The risks associated with using overhead ADSS optical fibres for the WAN backbone are considered higher than for OPGW or underground fibre as ADSS is more susceptible to damage (for example from vehicles impacting poles, bush fires, vehicles clipping the ADSS cable, bird damage).

The assignment of fibre segments in the WAN backbone and edge is required to meet the reliability and availability targets for services set out in section 0. The availability targets for zone substation SCADA and protection will require geographical fibre (or microwave) path diversity to provide continuity of services in the WAN backbone against the likelihood of fibre segment failures. In building geographically diverse paths, it is preferred to follow transmission lines between zone substations as the diversity requirements for communications are in-common with the N-1 redundancy provisions built into the 132kV transmission network design.

The physical communications network will be based on a multiple ring topology. The topology of the physical network for the MPLS network is depicted in section 5.

The reliability of the rings, and hence the physical fibre network, will depend on:

- geographical diversity of ring segments;
- number of nodes in a ring;
- reliability of individual ring segments.

4.1.2 Fibre count requirements

The estimated optical fibre counts for typical requirements for protection, the WAN and WAN edge are as follows:

Estimated OPGW usage between two zone substations (WAN)

Application	Fibre Count
Protection - No1 Primary Paths (two feeders)	4
Protection – No2 Primary Paths (long way around to provide geographic diversity)	20
Protection - Backup Paths	4
Syncro-phasor time synchronisation	2
WAN (MPLS network primary and backup paths)	4
ICCP to transgrid	2
Other Corporate BSD requirements	2
Total Minimum Requirement	**38**

Proposed implementation is to use 48 core OPGW.

Estimated underground fibre in the distribution network

The proposed WAN edge network uses a star topology connecting a hub in the zone substation to each individual distribution substation. A 48 core underground cable can therefore service up to 24 distribution substations in the one network. If and when the network needs to be expanded beyond 24 distribution substations, distribution hubs or switching can be employed in the WAN edge.

Proposed implementation is to use 48 core underground fibre optic cables in the distribution network.

4.2 Microwave links

Microwave is a technology that can augment the optical fibre network and provide communications to geographically difficult areas or where optical fibre is not viable. The current SCADA network has limited microwave and this can be retained to add resilience as the fibre optic network is rolled out.

Microwave is affected by weather and changing environmental conditions and therefore should not be used for protection.

Future microwave links will only be considered as a last resort, when fibre is not available.

5 MPLS network

To meet the business requirements needs outlined in Section 2, a multiservice communication network employing the MPLS technology is proposed.

MPLS is by far the most commonly selected WAN technology for smart grid implementations because of its,

- maturity and proven capabilities across large-scale industrial and enterprise networks,
- ability to support both traditional applications and next-generation requirements,
- ability to virtualize the WAN into independent sub-networks,
- centralized management of physical infrastructure and virtualized sub-networks,
- ability to enhance and become an integral part of the security framework across the WAN, and
- modularity for scalability and flexibility, as well as the ability to protect the overall system from domain failures.

MPLS has recently been adopted by BSD to segment sensitive Payment Card Industry client traffic from the corporate network. Currently BSD have MPLS configured between the data centres in Fyshwick and Greenway, and ActewAGL Distribution House. It is proposed to implement an MPLS network to electrical network sites in four stages as shown in Figure 1. The MPLS rollout will occur in conjunction with the proposed OPGW fibre rollout outlined in appendix A.

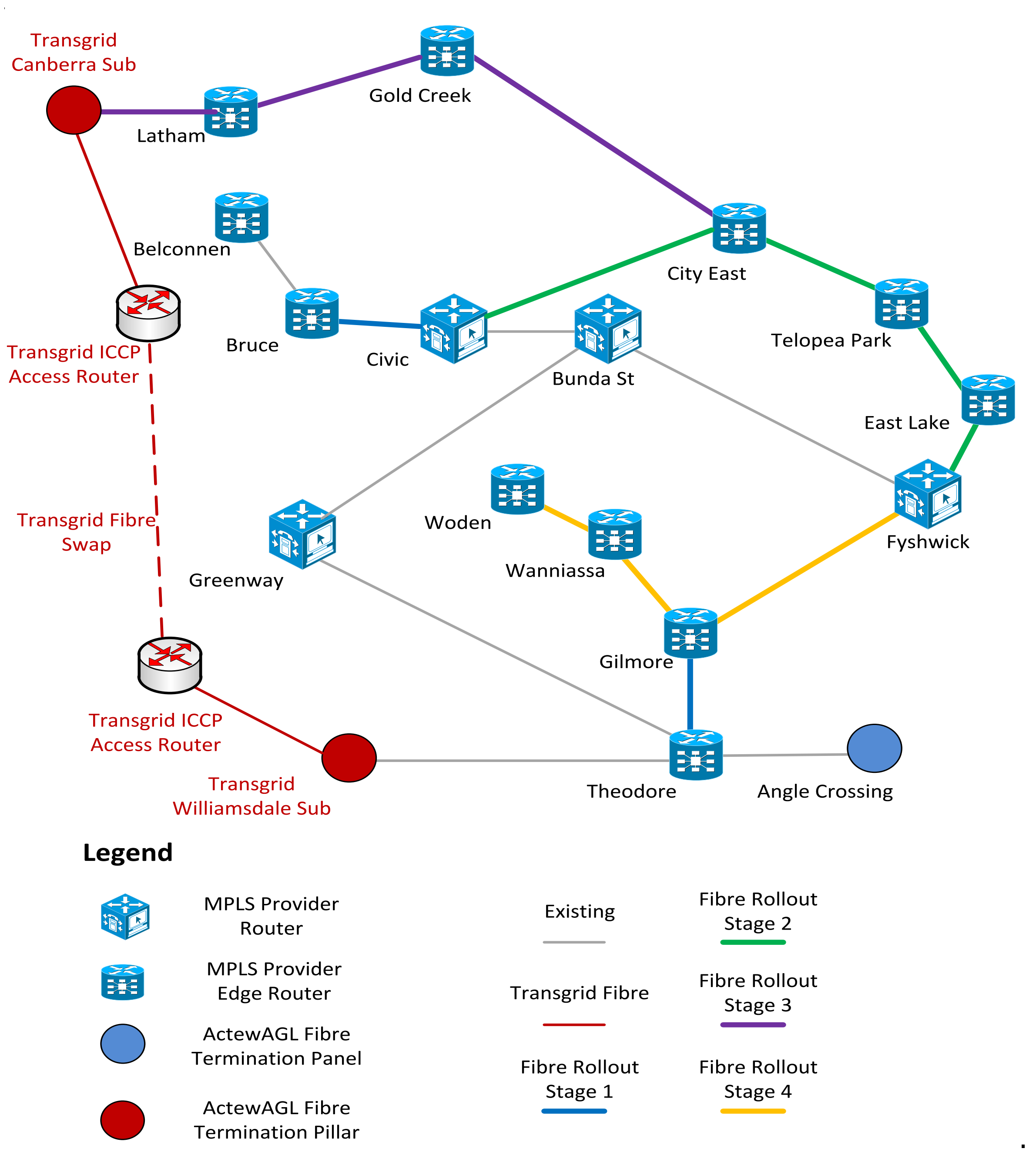


Figure 1 - Physical MPLS architecture for the WAN backbone

The MPLS network will have separate virtual private routed networks (VPRN) or virtual private LAN segments (VPLS) for each service required by the Networks Division. This will provide a layer of cyber security segregation between the separate business functions serviced over the shared infrastructure. Service and availability targets are outlined in the following section 5.1.

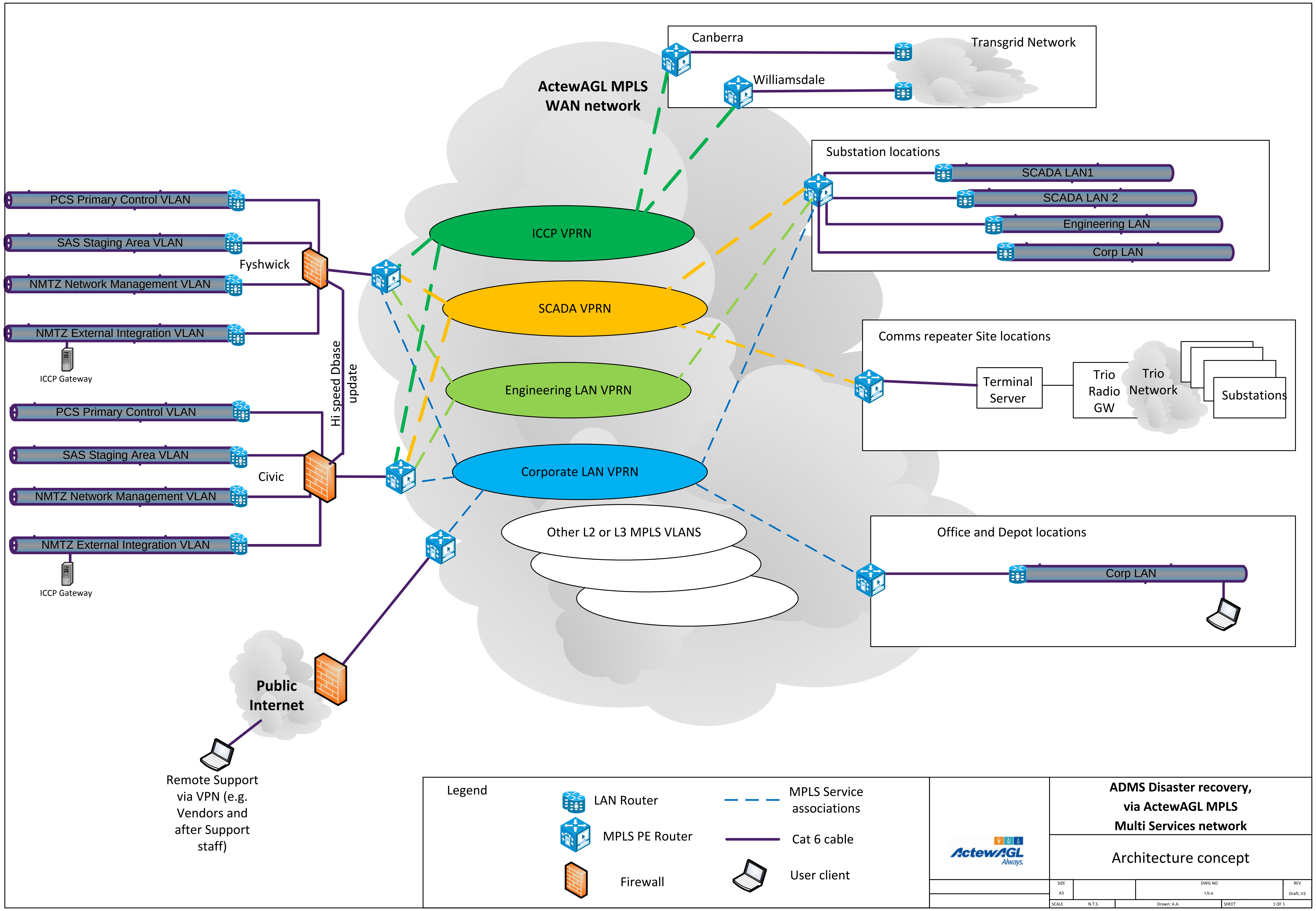


Figure 2 – Logical MPLS Multi-Service Architecture

5.1 Service Categories and Availability Targets

In order to reasonably meet the business requirements set out in section 2, the communications network needs to deliver the service availability, as outlined in the following table.

Service Category	Quality of service requirement	Availability requirement	Downtime per year
Protection signalling	Real time mission critical	99.999%	5.3 mins
Zone Substation SCADA	Near real time mission critical	99.98%	1.8 hours
Distribution network SCADA	Near real time	99.9%	8.8 hours
Advanced metering	Best effort	99% of meters within 10 minutes[6]	43.8 hours
Substation engineering access	Best effort	99. 50%	43.8 hours
Network video, switchyard monitoring	Real time non mission critical	99.50%	43.8 hours
Security video and remote access management	Real time non mission critical	99.50%	43.8 hours
Substation VoIP telephone	Real time	99.98%	1.8 hours
Corporate data	Best effort	99.50%	43.8 hours
Communication network management	Near real time mission critical	99.98%	1.8 hours

Notes:

1. Quality of service and availability requirements are in terms of individual endpoints
2. Real time traffic requires minimal latency and no jitter on the data stream
3. Near real time data can afford latency up to 1 second
4. Mission critical data shall have preferential availability to bandwidth and alternate communication paths

[6] As defined in the NSMP Business Requirements Work Stream, Smart Metering Infrastructure Minimum Functionality Specification

6 Proposed Implementation and Investment

6.1 MPLS WAN backbone

The MPLS and the supporting OPGW network will be rolled out in four stages over five years:

Stage 1 – July 2014 to December 2015

- MPLS connection between Civic (including DRF), Bruce and Belconnen substations.
- Leverages existing Bruce and Belconnen OPGW
- Provides services to Bruce and Belconnen substations
- Provides AMI backhaul for the Lawson South AMI rollout

Stage 2 – July 2015 to December 2016

- Extends MPLS connection to City East, Telopea Park, East Lake and Fyshwick control centre
- Leverages proposed East Lake stage 2 to Telopea Park
- Provides second communications path between Fyshwick control room and the Civic DRF. The existing Transact service will be retained as the alternate path
- Avoids investment in Civic microwave
- Provides services to City East, Telopea Park, East Lake substations

Stage 3 – July 2016 to December 2017

- Extends MPLS connection to Gold Creek and Latham substations and into TransGrid Canberra
- Provides ICCP service to AEMO via Transgrid replacing existing DSL service
- Provides services to Gold Creek and Latham substations
- Enables fibre swap with Transgrid to provide connection from Transgrid Canberra to Williamsdale. This will enable services to Angle Crossing, Theodore and Gilmore in Stage 4

Stage 4 – July 2017 to December 2018

- Extends MPLS connection to Gilmore, Wanniassa, Woden and Theodore substations
- Leverages proposed renewal of Theodore to Gilmore line that will include OPGW
- Leverages existing microwave at Tuggeranong Hill to provide backup path into Theodore
- Provides second ICCP service to AEMO via Williamsdale substation
- Provides services to Gilmore, Wanniassa, Woden and Theodore

Cash flows over the five year period for the MPLS WAN backbone (exclusive of OPGW installation costs) are estimated as follows:

Cost Category	Cost ($'000)					
	FY2014	FY2015	FY2016	FY2017	FY2018	Total
Design and Configuration	160	70	70	60	60	420
Network management Software	20	0	0	0	0	20
Stage 1 Installation	95	90	0	0	0	185
Stage 2 Installation	0	110	100	0	0	210
Stage 3 Installation	0	0	90	85	0	175
Stage 4 Installation	0	0	0	145	140	285
TOTAL	275	270	260	290	200	**1,295**

Site estimates include:

Cost Category	Cost
a. MPLS Router (Provider)	[redacted]
b. MPLS Rack	[redacted]
c. Battery/UPS Rack	[redacted]
d. Batteries and Rectifiers	[redacted]
e. Electrical/data fitout	[redacted]
f. MPLS site installation	[redacted]
g. Connection to SCADA	[redacted]
h. Fibre Termination Rack	[redacted]
i. Fibre lead-in installation (per OPGW)	[redacted]

6.2 Fibre optic provisioning to distribution substations in the WAN edge

The implementation of fibre optic to individual distribution substations (in the WAN edge) will be required in the following situations:

- Replacement of existing copper pilot cables with fibre due to failure of the metallic pilot (asset renewal of pilots with fibre);
- Additional business requirement such as chamber substation SCADA or advanced metering infrastructure (AMI);
- Additional network protection requirements such as protection intertripping;
- Network automation requirements such as flop over schemes for critical customers such as hospitals; or
- HV customer and generator network connections (normally separately customer funded)

Cash flows over the five year period for fibre optic provisioning to distribution substations/network are estimated in the following table. Projects for fibre optic communications will be specified in separate business cases covering one or more distribution substations.

Fibre optic provisioning to distribution substations	Cost ($'000)					
	FY2014	FY2015	FY2016	FY2017	FY2018	Total
TOTAL	300	350	400	400	450	**1,900**

6.3 SCADA Radio IP, Bandwidth & Security (DDRN)

Cash flows over the five year period for the IP upgrade of the Digital Data Radio Network (DDRN) is estimated as follows:

SCADA Radio IP, Bandwidth & Security	Cost ($'000)					
	FY2014	FY2015	FY2016	FY2017	FY2018	Total
TOTAL	120	120	120	120	120	**600**

Note: Migration of DDRN remotes to the chosen IP solution will only occur during the normal asset renewal cycle as assets fail or otherwise reach the end of their service life.

7 Recommendation

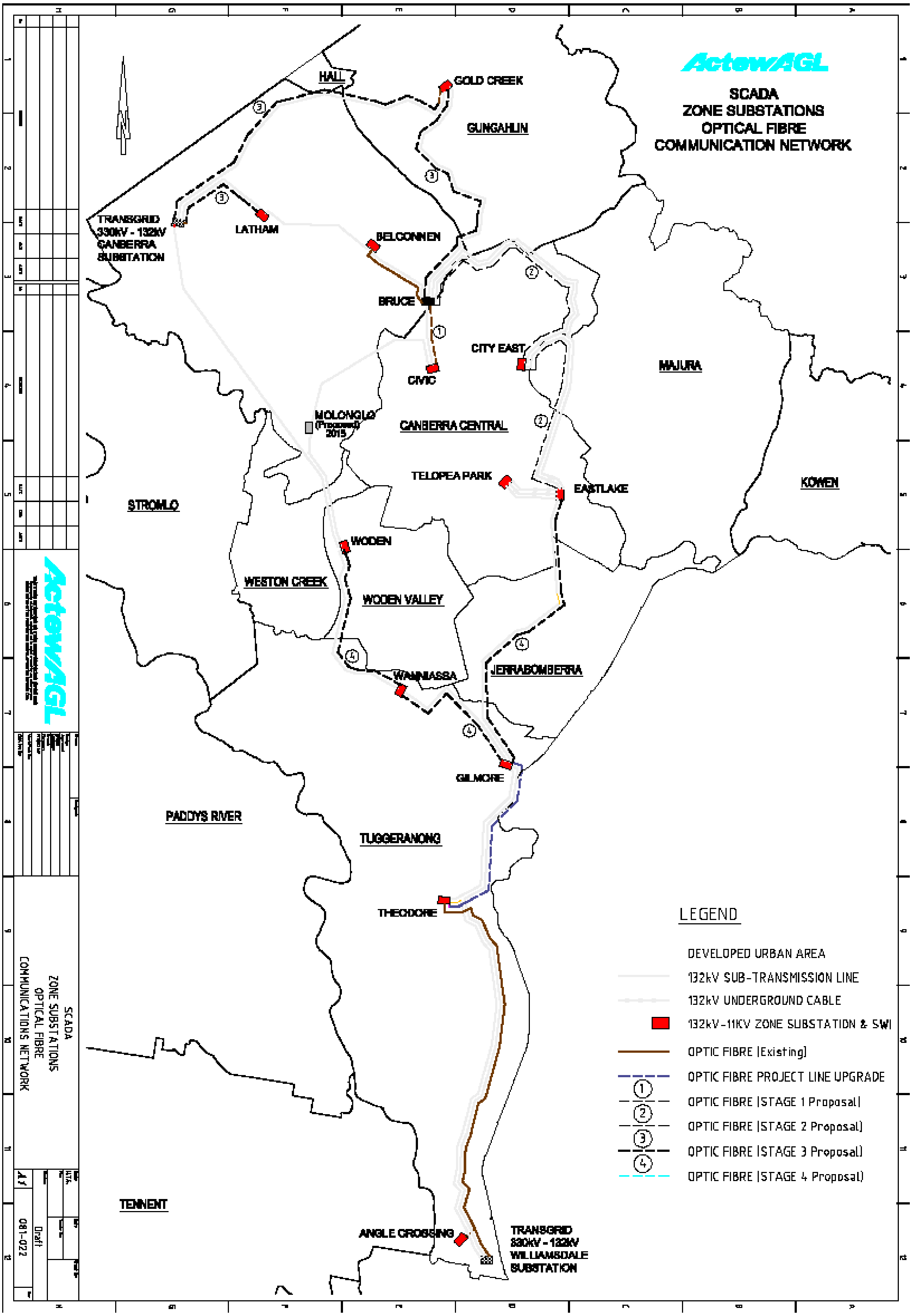
It is recommended that the business proceeds with the implementation of the following:

1. An MPLS WAN backbone covering the main control centre at Fyshwick, the future DRF facility at Civic and connecting to all zone substations for a total investment of $1,295,000 over 5 years;

2. The rollout of fibre optic to critical distribution substations (in the WAN edge) for a total investment of $1,900,000 over 5 years; and

3. The migration of SCADA DDRN radio remotes to an IP solution for a total investment of $600,000 over 5 years.

Appendix A – Proposed OPGW Network



4 Exemption – Designated Category A ICON Communications Infrastructure

There are restrictions around ActewAGL's access to the ICON network, and in accordance with the Telecommunications Act 1997 ICON can only provide access to designated category A links. These links are covered by an exemption titled *Telecommunications (Carrier Licence Exemption — ICON, SSICT and ACTEW Networks) Determination 2013 (No. 1.),* approved by the relevant Minister and specifically lists the only ICON links that are exempt from the terms of the Telecommunications Act 1997. The Department of Finance has indicated they does not intend to seek any further exemptions from the Act now or in the future. An extract of the relevant section of the determination is as follows:

Subject to the conditions set out in clause 6 below, section 42 of the Act does not apply in relation to the use of the Designated Category A ICON Communications Infrastructure, where the use is:

(a) by ActewAGL or ACTEW Corporation; and

(b) wholly or principally to support network resilience for one or more of the following purposes:

(i) managing the generation, transmission, distribution or supply of electricity;

(ii) managing the transmission, distribution or supply of natural gas in a pipeline;

(iii) managing the distribution of water;

(iv) managing the supply of sewerage services;

(v) managing the supply of storm water drainage services; and

(c) authorised in writing by:

(i) the Commonwealth as represented by the Commonwealth Department of Finance and Deregulation (or other replacement Commonwealth body or agency responsible for the Commonwealth's administration of the Designated ICON Communications Infrastructure); and

(ii) ActewAGL or ACTEW Corporation (as applicable).

Item 1: Locations - Designated Category A ICON Communications Infrastructure

Sub-item	***Location A***	***Location B***
1.1	*Fyshwick, ACT*	*Duffy, ACT*
1.2	*Fyshwick, ACT*	*Greenway, ACT*
1.3	*Fyshwick, ACT*	*Mitchell, ACT*
1.4	*Fyshwick, ACT*	*Stromlo, ACT*

Appendix C – Existing and Proposed Optical Fibres

A End	B End	Cores	Provider	Distance (km)
Fyshwick Building D	TransACT House Sub 9998	2	TransACT	20.24
Fyshwick Building D	Civic Zone substation	2	TransACT	15.32
Fyshwick Building D	Distribution Sub 9555	2	ICON	Unknown

Non-ActewAGL Distribution Owned Fibres used in Network

A End	B End	Type
Civic Zone substation	ANU Bulk Supply Sub 1254	Underground
Gilmore Zone substation	HMAS Harman Bulk Supply Sub 9819	Underground
HMAS Harman Bulk Supply Sub 9819	HMAS Harman substations 8754 and 9488	Underground
Bruce Switching substation	Belconnen Zone substation	OPGW
Theodore Zone substation	Mobile substation Williamsdale	OPGW
Theodore Zone substation	Tuggeranong Hill transmission site	Underground
Mobile substation Williamsdale	Transgrid substation Williamsdale	OPGW
Mobile substation Williamsdale	High Lift Pump Station substation	Underground
Causeway Switching substation	Telopea Park Zone substation	Underground

ActewAGL Distribution Owned Fibres used in Network

Proposed A End	Proposed B End	Likely Timeline	Type
Woden Zone substation	The Canberra Hospital Sub 5006	CY 2014	Underground
East Lake Zone substation	Telopea Park Zone substation (East Lake Stage 2)	CY 2015/6[7]	Underground
Gilmore Zone substation	Theodore Zone substation	CY 2015[8]	OPGW
Telopea Park Zone substation	Parliament House (subs 5, 8, 12 and 13)	CY 2014	Underground
Telopea Park Zone substation	Sub 5815 (DFAT)[9]	CY 2014	Underground

Near Future Optical Fibre Installations (planned/proposed)

[7] Subject to approvals for East Lake stage 2
[8] Originally planned to coincide with the EHV line upgrade, however this has been deferred from CY 2014 to CY2015 as the EHV lines are not at capacity as yet hence the upgrade is unjustified
[9] To be installed as part of the Telopea Park Zone to Parliament House fibre