Introduction

The example used in this pack is based on the typical network requirements for underground mining customers looking to establish an optical fibre backbone and Wi-Fi network platform to support automation programs.

There are two key design concepts used in this pack both of which are based on the typical network requirements for underground mining customers looking to establish an optical fibre backbone and Wi-Fi network platform to support automation programs:

1. Deployment of a Fibre Optic Backbone and Network Distribution Boards for high speed surface to underground communications
2. Deployment of Wi-Fi over Coax (WoC) for wireless broadband data.

The level of wireless coverage is completely dependant on the applications being used. The design and pricing example used in this pack is based on providing an all of mine coverage solution along with a price per metre for estimation purposes only. Please note that more specific pricing requires further design work.

Content

1. Underground Mining Trends & Concepts

Application Trends in Underground Mining

As context for underground communications strategy, the list below is some of the applications being utilised that require network connectivity.

Trends	Insight
People, Vehicle and Equipment Tracking	Tracking is about increasing productivity and safety. This is in the form of maximising the efficient use of vehicle assets, locating people and equipment quickly and taking advantage of Proximity Detection Systems (PDS) and Collision Awareness Systems (CAS). Vehicle tracking is also essential for Tele-remoting and Vehicle Automation. These systems require a level of wireless coverage to meet the accuracy requirements. The level of infrastructure required to determine which level something is at, vs to know within metres, its location anywhere within the mine will vary accordingly.
Tele-remote	Removes the operator from the hazardous area and relocates them to a secure and protected location where they can control the machine via remote control with the help of multiple cameras and sensors. This application is a major driver for high bandwidth, fast wireless networks that can be installed and setup quickly for more efficient mining.
Vehicle automation	By removing the operator from vehicles and running the entire trucking loop autonomously, mines can achieve significant operational cost savings and efficiency gains that are unheard of using traditional current underground trucking methods. Highly reliable, blanket wireless coverage is required for vehicle automation.
Fleet system analytics	Collecting information from the fleet, such as load weights, location and asset health data can be used for analysing and optimising underground mining production and processes. It delivers descriptive and predictive insights to improve operations.
Ventilation on Demand	Shorter re-entry times after blasting and electrical consumption cost savings are just some of the reasons driving the take-up of *Ventilation on Demand* systems in underground mines. A comprehensive fixed line network is required to provide connectivity to the PLC's controlling vent fans and louvres.

Application Trends in Underground Mining (continued)

As context for underground communications strategy, the emerging trends for industrial networks are outlined below.

Trends	Insight
Push-to-Talk (PTT), Voice (Phone) and Video over Wi-Fi	As Wi-Fi in the underground becomes more ubiquitous within a mine, Analogue or Digital Two-Way Radio (Push-to-Talk) and fixed line phones will be replaced by real-time IP based communications. Mobile calling in the form of Wi-Fi Calling and Video Calling will become more prominent in the suite of mine site communication technologies. IP based push-to-talk is quite common outside of Australia and will become more widespread in Australia as underground network coverage increases.
CCTV	Demand for CCTV in the underground is increasing dramatically. The drivers have been improving safety, processing, decision making and more centralised monitoring. This application has a significant impact on both the network bandwidth and Extra Low Voltage (ELV) requirements. The power for lights and cameras can be delivered by the physical data network in form of Power-over-Ethernet (PoE).
Automated dewatering	Automation of dewatering systems has become incredibly cost effective. Automation of dewatering systems can accurately track and trend system performance and allow for automated redundancy operations leading to increased availability and overall savings for the mine. These systems have similar connectivity to a Process Control Network, with connectivity to instruments and sensors, and managed in the sites SCADA system.
Electrical management	Understanding power usage and the condition of electrical equipment is becoming increasingly important to the operations of a mine. This is leading to an increase in underground substations, generally with protection relays being connected to networks for power management and maintenance applications.
Remote firing using the network	Wireless blasting system not only improves safety by removing people from harm's way, it improves productivity by removing the constraints imposed by wired connections and importantly is a critical pre-cursor to automating the charging process. Flexibility in being able to quickly retreat and deploy the wireless network is crucial for the success of this application.

Network Trends in Underground Mining

As context for underground communications strategy, the emerging trends for industrial networks are outlined below.

Trends	Insight
Centralised Operations Centres	Operations Centres are driving productivity improvements and continuous improvement across the mining business, by focussing on how the individual functions of the business (Operations, Marketing and Corporate) operate together most effectively as a whole. This approach is leading to production networks requiring similar centralised functionality as the telecommunications industry's adoption of Network Operations Centres (NOCs).
Wi-Fi coverage	Providing Wi-Fi in the underground environment has always been challenging. Surface-based approaches of using many Wi-Fi Access Points and omni-directional antenna systems are flawed in tunnel environments. Wi-Fi over Coax merges high speed Wi-Fi technology with the ease of use of Leaky Feeder cables. This technology reduces the number of Wi-Fi Access Points, time to deploy, robustness and is being turned to as a cost-effective alternative.
LTE in the underground	Some mine sites are pursuing LTE or 4G systems in the underground. These systems are currently very expensive, complex, require a lot of infrastructure and expertise to build and maintain such networks. Given the limited bandwidth they can provide, and increasing demand for high bandwidth ethernet applications, along with the move towards 802.11p for Connected Vehicles, LTE may only have a short-term future in underground mining.
Extending surface applications into the underground	Many applications are bridging the gaps between mining, processing and maintenance into site-wide applications. This is leading to a trend where surface-based network VLANs are being extended for use into the underground environment.
Change to network operating model due to increased network criticality	Networks are becoming increasingly more critical to production and safety systems. This trend has led to changes in the IT operating model: • IT support teams needed to become more involved in underground network and comms support, and operate 24x7 • First level network support functions are being transitioned to the underground electricians/comms techs, with Mine Control responsible for basic network monitoring tasks.

Applications and Connectivity Requirements

Each business requirement and supporting applications have been aligned against available technological options to meet these needs.

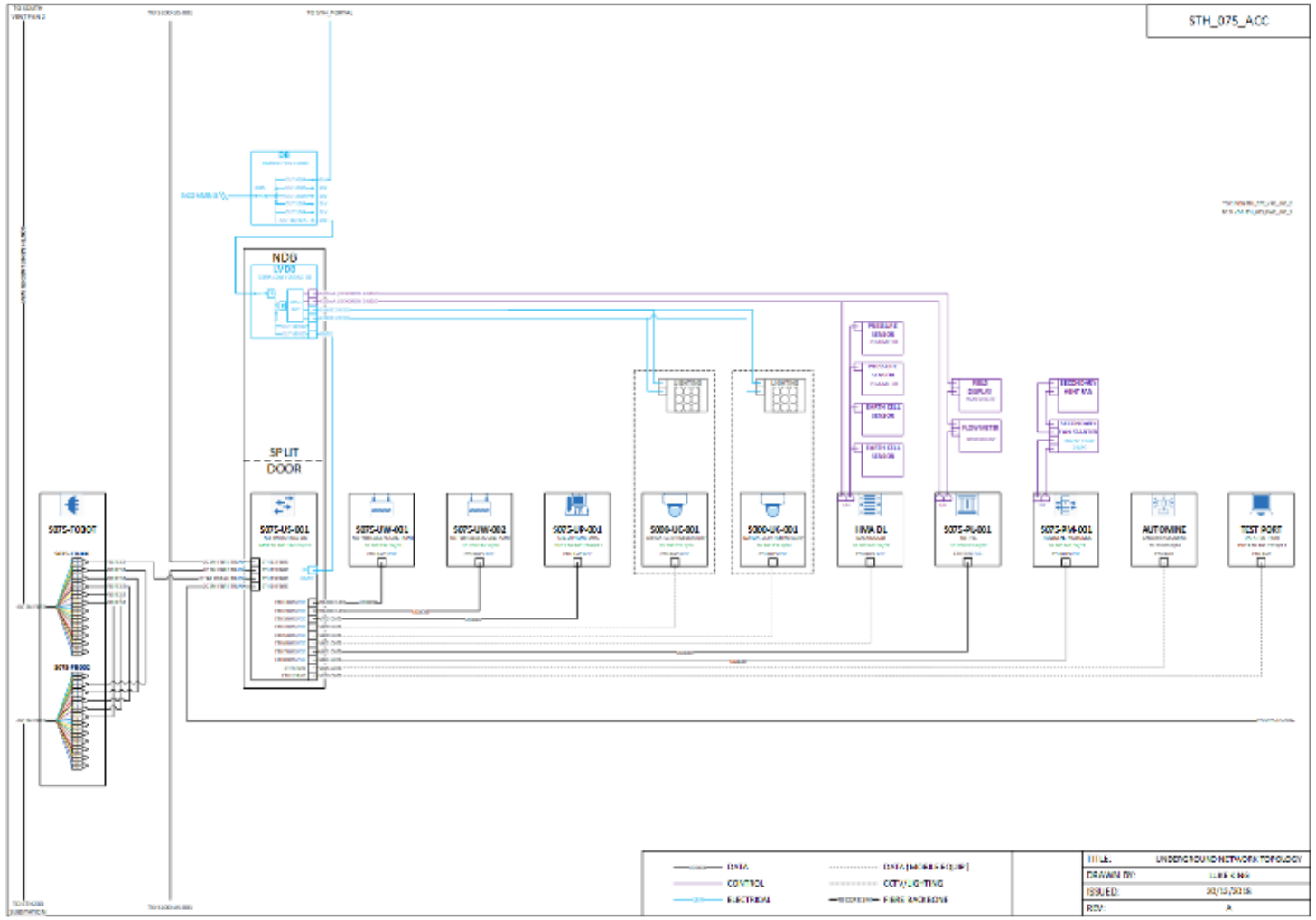
Mining Application	Connectivity Requirement	Technology Match
Truck Haulage Optimisation	Wi-Fi coverage of declines/inclines and levels up to loading points	Wi-Fi over Coax
Remote bogging from the surface over shift change and exclusion periods	Comprehensive Wi-Fi coverage of levels	Wi-Fi over Coax
IP-based firing system (to address reliability issues encountered with PEDS)	Cabled Ethernet or Wi-Fi connection to remote detonators	Ethernet Switch or Wi-Fi over Coax
Seismic system	Cabled Ethernet to seismic sensors	Ethernet Switch
PLCs for Pump stations, pressure sensors	Cabled Ethernet to PLC	Ethernet Switch
Fuel Bays – Fuel reconciliations and cameras	Cabled Ethernet to Fuel Systems and CCTV Cameras	Ethernet Switch
Future scope for truck automation	Wi-Fi coverage of declines/inclines and levels up to loading points	Wi-Fi over Coax
Remote operations centre	Cabled Ethernet to PLC and CCTV Cameras	Ethernet Switch
Phone lines	Cabled Ethernet to IP Phones	Ethernet Switch
Leaky feeder radio communications	Does not operate over IP Networks. Voice over Wi-Fi is a future option.	Wi-Fi over Coax / Wireless Access Points (Future)

2. Designing an Underground Network

Developing an *effective* Detailed Network Design

The diagram shows the typical detail required for an effective network design of a level. The drawing incorporates ***power***, ***instrumentation***, ***network infrastructure*** and ***cabling*** information into one schematic.

A detailed network design such as this is required prior to implementation as it describes the installation requirements, but is meant to be a “living” document and requires constant updating of changes to keep the information relevant for operations.



Underground Power Considerations

Power distribution is a critical component of an underground network and is often forgotten in the design and budgetary planning. Substantial low-voltage power distribution is required for both the network and the devices attached to the network. Such networks cannot be implemented successfully without implementing low and extra-low voltage power distribution.

It is very important in designing an underground network, that power, data and the devices being deployed are all considered.

3. Underground Optical Fibre Wi-Fi Network Design Concepts and Pricing

Network Design and Deployment

This process involves 2 main phases:

Phase 1 – Backbone Network Design Concepts

1. Power distribution is a critical component of an underground network and is often forgotten in the design and budgetary planning.

2. Underground networks cannot be implemented successfully without implementing low and extra-low voltage power distribution. The Venetzen's INDB™ will provide the Low and Extra-Low voltage reticulation as well as the network distribution for nearby levels required

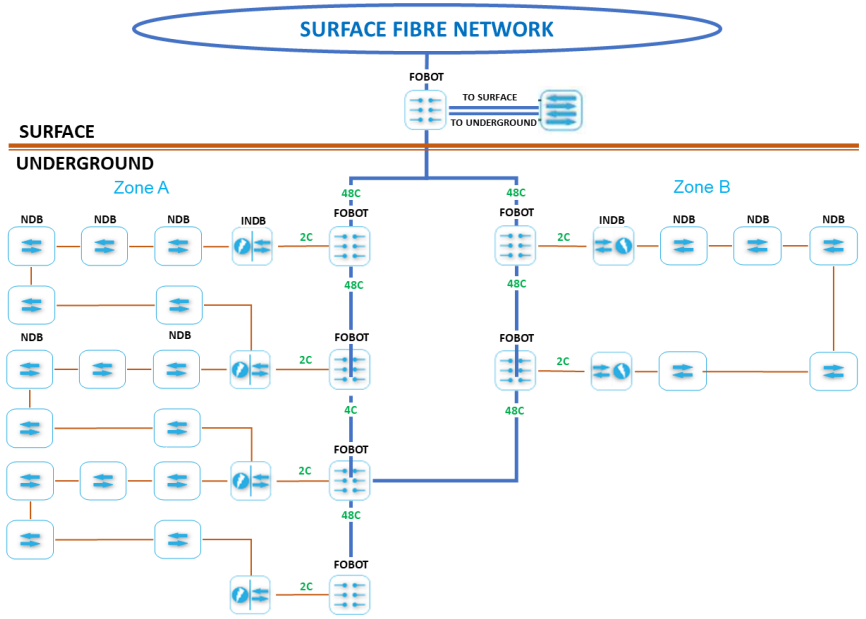
3. The surface to underground fibre optic backbone consists of Core Fibre Optic Cables run in a loop topology, with Fibre Optic Break Out Trays (FOBOT) and INDBs located in areas to provide the greatest access to future services.

Phase 2 - Deployment of Wi-Fi over Coax (WoC)

4. Each INDB can be daisy-chained with up to 5 x Network Distribution Boards (NDBs), which then they will be connected to one or more Wi-Fi over Coax (WoC) mini-headends.

5. This model provides a 7:1 ratio of traditional Access Points required to the one WoC for equivalent Wi-Fi coverage!

6. WoC Access Points can also be installed in transport declines to provide full blanket Wi-Fi coverage to optimise logistics and enable underground to surface autonomous solutions over one network



Description	Hardware	Estimated Costs (+/- 30%)
Phase 1 Deployment of a Fibre Optic Backbone and Network Distribution Boards	• 48C Fibre • Hybrid 2C Fibre + Copper • FOBOTs • INDBs • NDBs	Hardware / Cabling: $730,000
Phase 2 Deployment of Wi-Fi Over Coax (WoC)	• Vernetzen WoC • Vernetzen 2.4Ghz Wi-Fi Coaxial Cable (Price per 350m roll) • 6dBi Omni-Directional AE • Accessories	Hardware / Cabling: $450,000

Overall, the example design provides 21,700m of Wi-Fi coverage at $AUD20.73/m