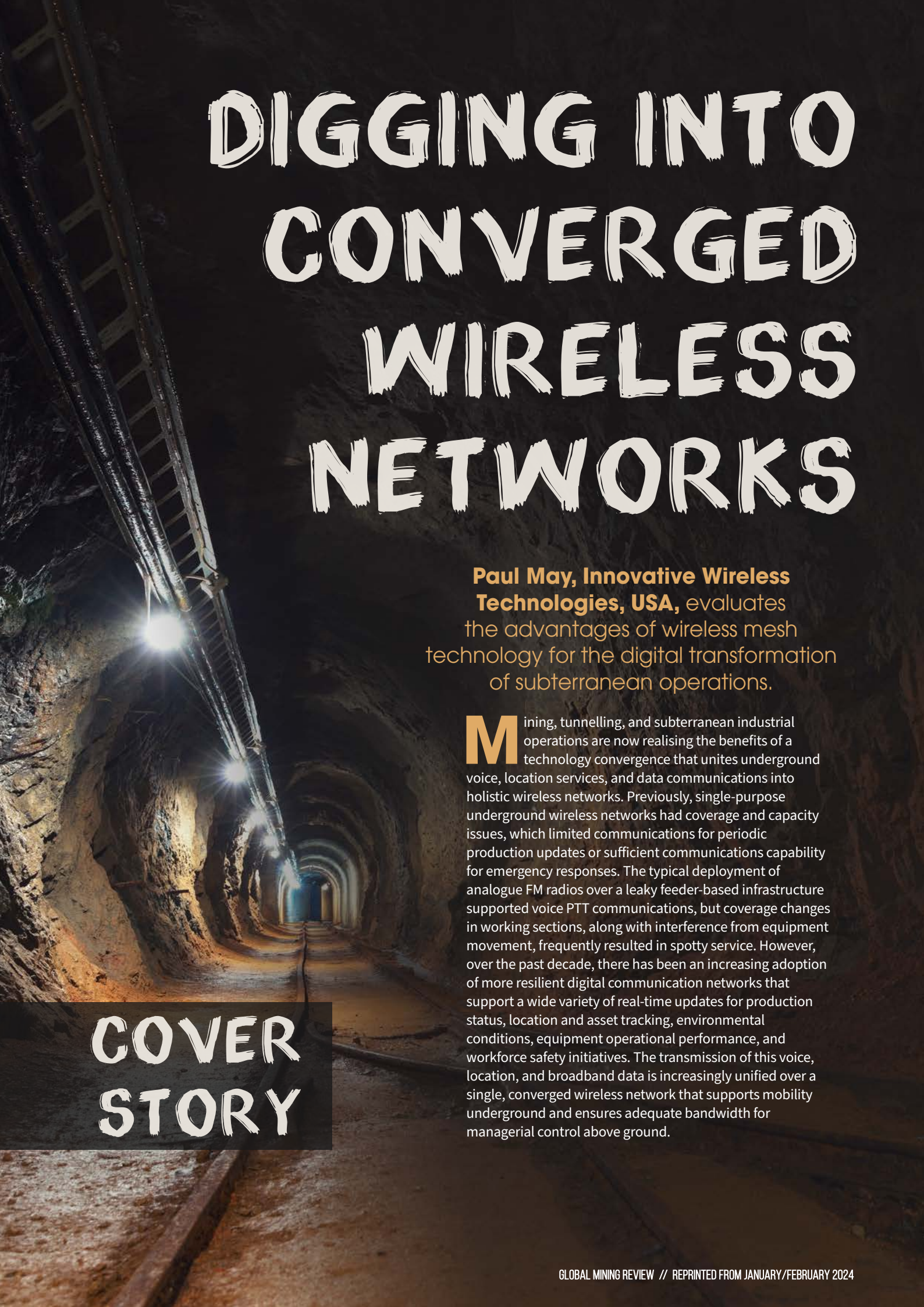

DIGGING INTO CONVERGED WIRELESS NETWORKS

Paul May, Innovative Wireless Technologies, USA, evaluates the advantages of wireless mesh technology for the digital transformation of subterranean operations.

Mining, tunnelling, and subterranean industrial operations are now realising the benefits of a technology convergence that unites underground voice, location services, and data communications into holistic wireless networks. Previously, single-purpose underground wireless networks had coverage and capacity issues, which limited communications for periodic production updates or sufficient communications capability for emergency responses. The typical deployment of analogue FM radios over a leaky feeder-based infrastructure supported voice PTT communications, but coverage changes in working sections, along with interference from equipment movement, frequently resulted in spotty service. However, over the past decade, there has been an increasing adoption of more resilient digital communication networks that support a wide variety of real-time updates for production status, location and asset tracking, environmental conditions, equipment operational performance, and workforce safety initiatives. The transmission of this voice, location, and broadband data is increasingly unified over a single, converged wireless network that supports mobility underground and ensures adequate bandwidth for managerial control above ground.

COVER STORY

Converged networks

Converged networks are not new, and for most industrial applications they are the fundamental component for an Internet of Things (IOT)-based digital transformation. However, the architecture of converged wireless networks varies widely based on environmental conditions and anticipated number of users, and above-ground technologies optimised for wide-area coverage and high user density have not transferred well for subterranean applications. When deploying wireless networks underground, the key performance indicator for success is radio frequency (RF) propagation. Technologies that work well above ground, delivering terrestrial coverage for large numbers of users, are not scalable downward to be cost-effective for the smaller workforces located in a tight subterranean environment. One wireless technology – mesh radio systems – hits the sweet spot for both underground coverage and cost-effective scalability for tens of users to thousands of users. For this reason, mining and tunnelling companies have adopted wireless mesh networks providing digital voice, data, and location services for mobile users.

Wireless mesh technology

Using wireless mesh technology combined with wireless and fibre backhaul, these converged systems are rapidly replacing the previous generation of stovepipe radio systems and legacy data networks that provided underground operations with limited services in areas of spotty, fixed coverage.

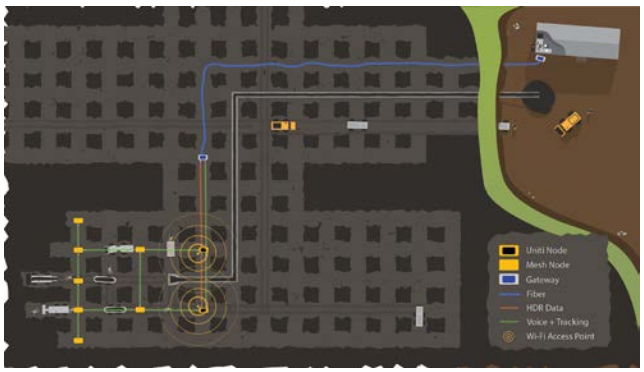

Figure 1. Wireless mesh nodes provide both voice communications and Wi-Fi. The node connects to the fibre network to provide connectivity to surface operations.

Figure 2. A wireless mesh network, combined with a digital point-to-point microwave network, provides connectivity across miles of rugged terrain, back to key above-ground locations.

Wireless mesh technology is a self-forming network, where radio networks establish the routing through the mesh links as the equipment gets installed. Self-forming allows the rapid deployment (and, as necessary in mines and tunnels, the re-deployment) of voice and data services in underground working sections. Mesh networks – which use multiple RF links to connect any two points – are also self-healing, which provides inherent redundancy. With mesh networks, when one RF link is blocked due to interference, the network nodes will automatically re-route the call across other redundant links. While the wireless mesh nodes, which establish the radio coverage area, can be extended for miles underground, wireless broadband, ethernet, and fibre backhaul provide cost-effective connectivity to the above-ground operations centres. Moreover, the broadband backhaul supports the data capacity for additional applications, such as sensor networks, production reporting e-forms, and video monitoring.

Case studies

Mesh and Wi-Fi integration

Examples abound of the use cases that take advantage of this converged wireless technology. For example, when the former Homestake gold mine in Lead, South Dakota, was converted into a deep underground science laboratory, the mining contractor for the lab required a wireless voice and data network to support the excavation of hundreds of thousands of tonnes of material, thousands of feet below the ground. Their solution was to deploy a wireless mesh network using Innovative Wireless Technologies, Inc. (IWT) *SENTINEL* Uniti Nodes to provide voice and Wi-Fi communications. The *SENTINEL* Uniti Node delivers both coverage and local wireless backhaul. At convenient locations underground, the *SENTINEL* system connects into a customer-provided fibre network to supply connectivity with the surface operations centre. The *SENTINEL* Uniti Nodes provide the voice coverage needed for mining operations and data connectivity for raise bore machines and other critical equipment. As the excavation proceeds, the SENTINEL Uniti Nodes allow for the movement of the primary coverage areas with minimal (or no) gaps in coverage, and without having to re-route the hardwire backhaul.

Mesh and microwave integration

Another example of the converged voice and data network is in use for a multi-year improvement project for the San Francisco Mountain Tunnel (SFMT) in California. The SFMT supplies water from Sierra Nevada foothills to 2.7 million San Francisco and other Bay Area customers. The project is necessary to repair the 19 miles of the 100-year-old aqueduct, as well as to construct new tunnels to facilitate maintenance and improve water quality. To complete this work, the tunnelling contractor needed a communications deployment network that supported both above-ground and belowground operations. The SFMT is in remote mountain canyons and the communication system needed to be efficiently installed and removed during winter shutdown months when the tunnel is drained and available

for maintenance. The chosen solution was an IWT *SENTINEL* mesh network combined with a digital point-to-point microwave network to provide connectivity back to key above-ground locations. The *SENTINEL* network delivers voice communications, as well as personnel and asset tracking underground. To supply the wireless network coverage, the tunnelling contractor selected IWT Battery Mesh Nodes, which have internal and external battery options that allow standalone deployments for weeks or months without replacement or recharging. With the Battery Mesh Nodes, coverage areas can be deployed in a matter of minutes, as the nodes are strung up along the tunnel. Key also to the solution was the use of solar-powered digital point-to-point microwave on towers along the tunnel path. This backhaul network connected the underground elements of the radio network during the winter maintenance period, as well as providing connectivity for the aboveground elements of the radio network throughout the year.

Mesh and land mobile radio integration

Converged digital networks not only bring innovative technologies to subterranean operations, but they also bring additional service life to existing investments. An example of this can be found at a limestone mine in Sherwood, Tennessee. This mine, which produces high-calcium lime for agriculture and industrial and mining dust control applications, needed to improve communications for their underground operations, but did not want to replace their legacy above-ground radio system. The mine selected a *SENTINEL* mesh radio for their mining operations, and IWT provided a digitally connected Land Mobile Radio (LMR) Bridge to supply the patching with existing above-ground analogue LMR network. The LMR Bridge allows for a direct interconnection between the two radio networks, utilising a platform that can be, if desired, further network-connected for audio distribution to multiple monitoring points. Additionally, *SENTINEL* network extensions go beyond LMR to include telephone and public address (PA) networks as well. With IWT's Phone Connect feature, authorised *SENTINEL* handset users can initiate or receive telephone interconnect calls. IWT customers can also extend their PA system as an input on the radio network that allows announcements made over the PA system to pass to *SENTINEL* handset users as well.

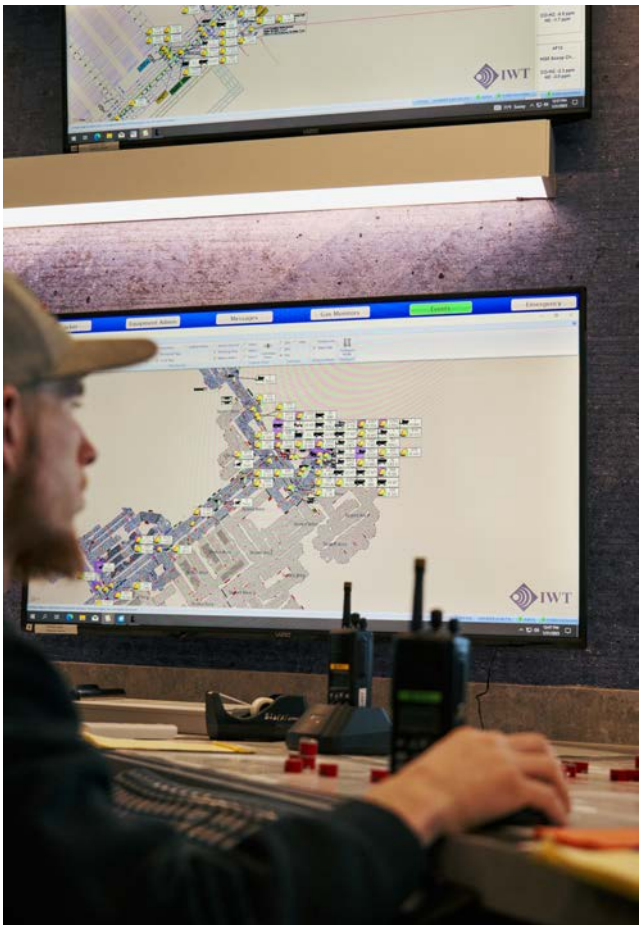

Figure 3. Automated location services provide asset tracking for optimal usage, while personnel tracking supplies critical information for emergency responses.

Mesh and third-party integration

The data side of a converged network can also be extended from the wireless mesh network though ethernet or fibre connections. One data use case is IWT's Wireless Gas Monitors (WGMs) used in coal mining and other potentially hazardous environments. In Grafton, West Virginia, metallurgical coal mines have implemented WGMs connected through the mine's *SENTINEL* voice communications and tracking radio network. If the WGM senses a gas level that meets the alarm threshold for the monitored gas, the WGM alarms are transmitted digitally through the radio system to dispatch operations directly to worker's radio handsets. The mine further extended the alarms from the WGMs to connect their FactoryTalk™ HMI software using IWT's ServerLink™ application. ServerLink supplies connections to industrial automations and control systems using Open Platform Communications – Unified Architecture (OPC-UA). OPC-UA is a secure transport protocol that provides a standardised interface for *SENTINEL* WGMs to report status updates into comprehensive mining or industrial automation control and monitoring management systems.

Digital transformation

The deployment of converged communications systems is a critical step in the digital transformation of the mining and tunnelling industries. These communication systems – defined by the integration of voice, location services, and data – allow mining and tunnelling operations to simultaneously increase both safety and efficiency. Workers using wireless mesh networks rely on scalable voice coverage, audio voice quality, and priority for emergency communications. Automated location services provide asset tracking information to determine optimal usage routines, while personnel tracking supplies critical information for emergency responses. Data from equipment that connects to converged networks autonomously publishes production data, provides status updates, and, through integrated analytics, transforms that collected data into actionable information. Using the disruptive innovation granted by a converged network, mines, tunnels, and subterranean operations can move into the information age to become a high-technology industry. GMR