WHITE PAPER

No Point of Failure:

Innovation and Convergence in Mining Communications

Much like the strata of rock visible in a mine, modern mining communications rest on layers of communications technologies, introduced over time to improve the safety, efficiency, and productivity of mining operations

Ground-breaking new technologies will continue to emerge, but earlier technologies continue to perform the function they were intended for, and do not necessarily become obsolete; indeed most remain relevant and are maintained, advanced and upgraded by manufacturers.

So, rather than the development of a single, ideal technology, the future of mining communications lies in the smart integration of multiple new, and existing tools and techniques, as Unified Critical Communications combines mining operation technologies into a network of networks.

In this paper, we will discuss:

- Layers of mining communications
- The historical mix,
- Exploring wireless technologies,
- Tying it all together with Unified Critical Communications,
- Why technology partnerships matter

The layers of mining communications

It is tempting to believe that, like consumer technologies (TVs, smart phones, recording devices) each industrial communications technology will inevitably be replaced by a single technology that builds on the past and captures all future communications requirements.

But the reality in this industry is very different. Mining requirements continually evolve so it can never be possible to capture all the industry's communication needs in a single technology. Even as exciting new technologies become available, it makes little business sense to dispense with existing processes and equipment that continue to provide critical functionality.

The future of mining communications lies in harnessing the benefits of many different platforms, technologies and applications in a single unified platform – Unified Critical Communications (UCC). This is not a distinct new technology or single product, but a platform where diverse products and communications methods (legacy, current and new) work together to present a consistent, unified user interface and experience.

To understand what this will mean, it's important to understand existing and new technologies, their strengths and weaknesses, how they have evolved, and what part they will play in this game-changing approach to mining communications.

When any business invests in technology, it is to solve a specific problem, or unlock a specific benefit. Regardless of resource, scale, location, or life cycle, every mining company seeks a consistent set of benefits, each of which is dependent upon sound, reliable, cost-effective communication:

- better workplace health and safety
- environmental sustainability
- improved productivity
- reduced operational cost
- increased integration across business
- efficient deployment of skilled staff

How communications systems are chosen depends on each company's and each mine's distinctive history, environment, and business requirements, as well as what communications resources are required for the various phases of a mine's lifecycle. From the early prospecting phase, to setting up semi-permanent camp, then constructing a permanent facility, launching into production, and finally de-commissioning a site, the communications coverage and services escalate with the number and kinds of people and equipment involved.

So it is not uncommon to find mining companies relying on multiple communications technologies of various vintages in diverse combinations. (Some statutory legislation even demands a mining operation to install multiple different communications systems in case one fails.)

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The Historical Mix

In the twilight of the 19th century, frequent mine accidents brought social and political pressure to bear. In response, mine operators introduced battery-powered bell and whistle signalling so that miners could exchange information. Safety and productivity demands pushed development of wired systems to convey voice, and even provide simple automation and remote control. But the physical vulnerability of cabled systems drove the evolution of increasingly-sophisticated wireless systems.

Most recently, converging wireless communications, computing and networking has created a market for IP-connected devices. Using IP for interconnection, innovative system design that integrates multiple technologies is now possible. Mining companies generally cannot afford the interruption, time, or money involved in swapping serviceable old technologies for new ones. These legacy systems can often be adapted, or integrated with later technologies.

Legacy technologies that are IP-connected and integrated earn fresh relevance as Unified Critical Communications – the integration of the distinct technologies employed by a mining company so that they appear and function as one single, secure, managed system. This approach not only extends the life of legacy technology that retains useful function, but also avoids the risky, “big bang” changes that mission-critical organizations dread.

Exploring wireless technologies

LAND MOBILE RADIO (LMR)

Widely used in open pit mining, LMR has surface coverage characteristics that only satellite can better. Operating in licensed VHF or UHF frequencies, equipment is very rugged and offers mine-specialized, terminals and infrastructure, including intrinsically safe. For surface communications with clear line of sight, radio can connect up to 40km - much further if a network of repeaters is installed.

Just a year after Alexander Graham Bell patented the telephone, the first underground mine telephone network was installed in Glace Bay, Nova Scotia. By the 1930s, Ericsson Telephones Ltd was offering a full suite of intrinsically-safe mining products. More than 80 years later, their business benefits still resonate:

“The importance of telephone systems as essential parts of mining plants cannot be reiterated too often, not only on account of the greater safety they insure but also in the interests of efficiency and economy. (Ericsson Booklet 14A (1934))”

However, underground, twisting tunnels and reflecting walls are an RF propagation nightmare. Traditionally, the underground "leaky feeder" coverage solution uses coaxial cables that have sections of shielding removed at regular intervals to allow RF signals to leak in or out.

This is a highly-developed wireless technology which is fully digital, from its flexible IP networking, SNMP-based network management, to advanced security features. Crucially, open standard, digital interfaces enable radio equipment to connect directly to other systems and devices.

In mining, radio has moved well beyond its voice-only origins. Among many other examples, it can:

- manage fleet communications and vehicle tracking,
- extend SCADA networks,
- use built-in RFID and GPS to track people and equipment,
- support physiological monitoring,
- remotely control ventilation and pumps,
- provide the comms channel for remote blast initiation.

New products now integrate digital technologies such as DMR with smartphones, PDAs and tablet PCs into an overall communication solution. Even the leaky feeder solution has been re-visited, as radio combines with VoIP over WiFi to create fully wireless underground communications. Despite its integration-friendly digital advantages, radio has some fundamental limitations:

- Data performance is typically constrained to 9600 bps, so LMR cannot support applications requiring broadband data such as streaming video.
- For data applications latency between sender and receiver is higher than some other technologies, ruling out some future automation, real-time remote operation, and big data applications that mining is interested in pursuing.

These limitations are offset by LMR's wider coverage, less interference and portables with longer shift life. Rugged morphology designed for mission critical use ensures infrastructure and terminals can withstand harsh mine environments for longer life and higher return on investment.

WIFI

Mining companies have found uses for WiFi outside of the office, as the primary backbone technology for communicating devices other than computers, such as heavy mining equipment in the field

A wide variety of devices can be made WiFi-capable, connecting to each other or to the Internet. For example, German mining company, Deutsche Steinkohle, has several hundred WiFi hot spots in its coal mines; in Kiruna, Sweden, WiFi-linked underground drills relay location data to a control room computer at the surface.

As it operates over unlicensed spectrum, WiFi is prone to interference from other communications devices, such as remote vehicle starters, cordless phones, and security cameras occupying the congested 2.4 GHz band. However, when integrated with LMR, WiFi can address LMR data shortcomings, while LMR provides the range and resistance to interference that WiFi lacks.

Data rates may be impressive, but WiFi range is not. Extenders, increased transceiver power and directional antennas can help, but greater range comes at the expense of data rate and capital cost.

Nevertheless, the ability of WiFi to form ad hoc connections makes it a natural choice for linking WiFi -capable devices into a robust wide-area mesh network. With their myriad redundant connections, the inherent resilience of mesh networks can offset its short range and interference susceptibility.

WiFi mesh networks vary widely from a small group of interconnected sensors to very large, where each node acts as a wireless router, distributing a signal through the network. Dynamic routing determines the best route for data exchanges, and nodes can be mobile (for example vehicle-based); compact nodes attached to trucks, excavators, and loaders operate even while equipment is moving.

The chief advantages of a mesh network are its resilience and coverage. With multiple paths and each device taking on routing duties, transmissions are not blocked by a damaged (or inaccessible) node – they simply take an alternative route. Expansion has no impact on node connections and may improve coverage.

However, with so much built-in redundancy, mesh networks are expensive to deploy and tricky to manage because configuration change constantly, particularly with mobile nodes. This can cause latency issues for time-critical data or for system support in remote locations.

SATELLITE

Increasingly, mining companies operate in remote locations with little – if any – telecommunications support. Satellite can connect mobile exploration teams, exploration and construction camps or remote production facilities with the wider organization, and for FIFO (Fly In Fly Out) workers, with families back home.

- A mobile geologist in remote Western Australia uses a portable terminal for tele-conferencing or to access the Internet via Iridium satellite network.
- In South Africa, a network of VSAT (Very Small Aperture Terminal) ground stations exchanges signals via satellite with a master hub at an operation center, or meshes with other VSAT terminals to provide integrated communications for a remote mining camp or production site.

VSAT delivers ultra-wide coverage, is not prohibitively costly, and can be installed and expanded relatively easily. Limitations include:

- high latency (roughly 300-400ms to and from the satellite),
- the need for clear line-of-sight,
- vulnerability to adverse weather and rain fade,
- potential for security breaches,
- the satellite is a critical single point of failure.

"...when integrated with LMR, WiFi can address LMR data shortcomings, while LMR provides the range and resistance to interference that WiFi lacks."

4G LTE MOBILE NETWORKS

4G LTE (Long Term Evolution) is an open standard, digital, cellular technology that promises to be a game changer for specific mining applications. It offers essential features for the mine of the future:

- 4G (and increasingly 5G) mobile communications with high-capacity data and voice,
- mobility support including fast, reliable handovers,
- low latency,
- excellent resilience,
- built-in Quality of Service (QoS) capability,
- low power consumption for terminals,
- exceptional spectrum usage,
- ability to utilize licensed spectrum (avoids interference),
- larger link budgets than WiFi, providing great coverage
- large frequency agility, and ranges of bandwidths supported.

Smartphone users are familiar with LTE's fast Internet access, impressive downloads, and broadband features such as high-resolution streaming video across public networks. Mining companies are beginning to invest in private, non-shared LTE networks that guarantee security, access, and control.

However, LTE also has some significant drawbacks.

- Available spectrum for private LTE networks is limited. (There are some exceptions; in remote parts of the world, and for underground mining operations LTE spectrum licenses are available.)
- While individual networks vary widely, typically LTE requires substantially more towers to achieve LMR-equivalent coverage.

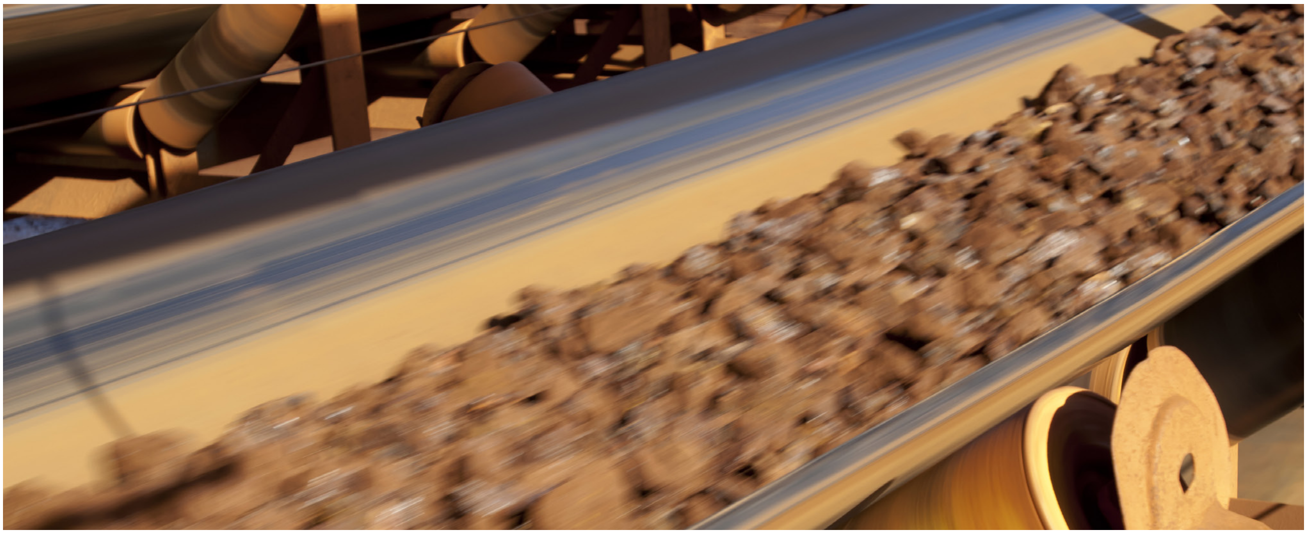
- Infrastructure has been prohibitively expensive compared with other technologies (although these costs are rapidly reducing as more efficient infrastructure products are introduced).
- Most mining applications (such as fleet management) operate on Layer 2. LTE installations require additional networking to ensure devices will work on Layer 2, increasing complexity and computing requirements to a network.
- Coverage blackspots are challenging, with large mobile equipment, and confined areas like drop cuts, high walls and large waste dumps necessitating hybrid solutions.
- Data download is designed to be faster than upload (driven by commercial carrier networks) – the opposite of mining needs. Mining applications typically upload significantly more data than they download. TDD (time division duplex) techniques, these ratios can now be adapted.

Communications networks that integrate existing with new (or upgraded) technologies will go a long way to resolving these technical limitations. As public safety operators have found, pairing LTE and Land Mobile Radio significantly improves coverage while building in redundancy. Consequently, LMR manufacturers are responding to demand for products (including intrinsically safe subscriber devices) that support digital LMR, WiFi, LTE and satellite.

In many situations, LTE could potentially replace the WiFi mesh networks currently providing wireless data above and below ground.

To retain these functions and incorporate the power of LTE, it will be necessary to tackle the complex integration between WiFi and LTE. This is potentially made more complex by LTE's asymmetric throughput design (high download/low upload) – precisely the opposite of what is required for mining.

Integrating a layered, hybrid solution can resolve coverage and efficiency issues, such as blind spots created by moving shovels, and drop cuts. That might consist of WiFi access points that communicate directly to WiFi clients, which are also capable of LTE communications.



While underground wireless voice and data communications have traditionally been through leaky feeder or WiFi, LTE could change this. New LTE standards for wireless sensors include low powered and less expensive devices (e.g. battery-powered sensors) to operate on cellular carriers, thus bringing cellular underground. This is achieving unprecedented energy efficiency, so that communicating devices (such as small IOT sensors) can run off the same battery for years.

Given the capital required, and its relative development immaturity, it is unlikely that the majority of mining companies will completely jettison their existing communication for single, universal LTE devices in the foreseeable future. As US public safety agencies are discovering with FirstNet, it takes time for new platform issues to be resolved. Private Industrial LTE has scarcely begun this process, but mission-critical features such as Mission Critical Push to Talk (MCPTT), Mission Critical Data (MCDATA) and Mission Critical Video (MCVIDEO) will be worth waiting for.

"Fortunately, layered networks that integrate existing communications with new or upgraded technologies will go a long way to resolving these technical limitations. "

FIFTH GENERATION LTE (5G)

4G currently provides mining companies with the connectivity to safely run their operations, but Fifth Generation (5G) is the next step in mobile communications and a key element in the Industrial Internet of Things. 5G is set to improve upon the capacity and latency seen in 4G, and although standards are still evolving, commercial and consumer trials are underway and rollouts have begun.

The stated objectives of 5G are a perfect fit for digital mining into the future. We can anticipate that - with additional spectrum made available by governments - commercially-deployed 5G networks will provide significant benefits over its predecessor. For instance:

- support for more connectible devices (x10-100),
- faster data (x10-100),
- greater data volumes (x1000),
- lower latency (x5),
- better battery efficiency (at least x10).

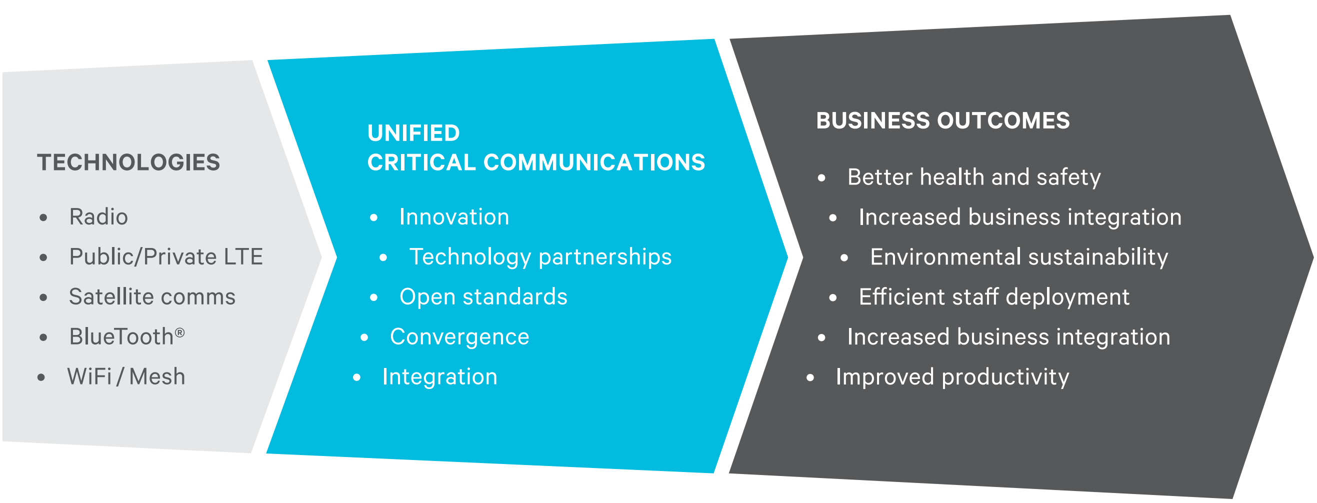
These are all critical for machine-to-machine (M2M) communication, smart real-time analysis and control, and the advanced AI-driven automation that mining companies see as the path to sustainable growth.

Tying it all together with Unified Critical Communications

This brief survey of mining communications technologies illustrates how mine operations are accustomed to a multiple technology approach to meet their complex requirements. With continuity of communication so critical to mining businesses, it is easy to see why integration of existing communications systems is a safer option than wholesale switching of technologies. We can see how 'legacy' technologies – such as telephony and wired control systems – continue to play an integral part in the mix of technologies that modern mining operations employ.

Your next logical step is integration, to combine your existing and new communications resources in innovative ways. Integration enables overall mining communications systems to be upgraded, without compromising trusted communications methods. Indeed, any time communications are upgraded, enhanced or expanded is an opportunity to integrate.

- Expansion – to extend the range of communications (e.g. satellite)
- Migrating to newer updated versions of the same technology – as an intermediate step to transition a communications system from one technology to another (e.g. in LMR migrating from analog MPT1327 to digital DMR, in LTE moving from 4G to 5G)
- Redundancy – adding a fallback communications option when other systems go down (combining LTE and LMR for a resilient voice data network). (Regulators may require a fallback option to be in place.)
- Open standards – when sites are under construction or companies merge (or agree to share communications) enabling them to collaborate and share resources without a wholesale replacement of equipment (e.g. analog FM interoperability channels for construction crews).
- Unifying – adding new functionality to the current system, with new applications, new services, or new data capabilities (e.g an application that automatically selects the best bearer to talk over, so users no longer need to work out which bearer has the best signal in any location.



Buying into a new, "Swiss-Army knife" multi-function product that promises to do everything is a considerable gamble. It requires a costly changeout of equipment, training, and processes; risking that existing processes and systems may not work as they had done previously. Unlike other industries, mining operators cannot afford even minor interruptions to their communications systems.

Piecemeal integrations can lead to a collection of communications subsystems that are internally integrated, yet managed separately, and only loosely connected with each other. Getting them to work together – coordinating overall performance, monitoring security, and administering consistent access control – is complex. Moreover, integrations implemented through proprietary interfaces, can severely constrain interoperability with open-standards equipment, locking mining companies into buying only from vendors that support their proprietary connectivity, into the future.

To move beyond piecemeal integrations, UCC can seamlessly integrate any combination of voice, data, text, images, or video and automatically selects the best network to deliver these quickly, reliably and securely across various devices, endpoints, and applications. A mine worker or application does not need to decide which technology is most suitable for a communication. Instead, without further intervention, a UCC system dynamically adopts whatever is the best delivery method available at the time, whether it is LMR, WiFi, LTE, cellular etc. In this way, Unified Critical Communications retains the most appropriate aspects of existing technologies while accommodating future developments.

"… integrations implemented through proprietary interfaces, can severely constrain interoperability with open-standards equipment, locking mining companies into buying only from vendors that support their proprietary connectivity, into the future."

Why technology partnerships matter

How does a mining company successfully develop their Unified Critical Communications solution? Key partnerships between technology providers are critical, allowing mining companies to leverage developments across and within industries and technologies. For mining companies, the best partnerships are founded on open standards that will create flexible, future-proofed, multi-source solutions.

Driven by IP and new paths for connectivity, a broad range of technologies (such as computing, the Internet of Things, artificial intelligence, mobile communications, automation and sensors networks) are advancing exponentially and converging, opening up incredible prospects for mining.

By developing strong relationships with a diverse range of technology partners, Tait Unified Critical Communications take full advantage of these possibilities, offering our mining customers solutions that safeguard their business continuity while embracing change.

"… Unified Critical Communications can seamlessly integrate any combination of voice, data, text, images, or video and automatically selects the best network to deliver these quickly, reliably and securely across various devices, endpoints, and applications."

ABOUT THE AUTHOR

Now an independent consultant based in New Zealand, Dr Jan Noordhof was Principal Consultant for Tait, specializing in technical solutions for public safety, utilities, mining, and oil and gas sectors around the world. He has held a variety of senior commercial and engineering roles in both analog and digital radio. Dr Noordhof has worked in TETRA development, software engineering, systems programming, telecommunications and embedded system design, and has taught at a number of universities.

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