WHITE PAPER

Digging deeper with digital:

How the resource extraction industry is harnessing the power of digital communications

EXECUTIVE SUMMARY

Faced with falling revenue and profits, the mining industry has turned to technology changes driven by today's communications revolution to grow future business.

For almost a decade, companies which made money out of digging for coal, iron ore, diamonds, gold and other commodities have tumbled from their position as $1.8 trillion market value leaders to investment losers, simply treading water to stay afloat. Basically, demand dropped sharply, commodities prices slid, investors withdrew, while operating costs remained high.

Clearly, pricing and demand remain outside the control of mining companies. But the industrial problems they face also present opportunities to reduce risk and take control of future business.

This paper summarises the challenges this industry faces, describes solutions already implemented, and validates the critical role that communications will play, in the mines of the future.

Find out about:

- Deep Fault Lines – Industry Challenges
- Prospecting for New Solutions
- Developing the Mine of the Future Today
- Communications Now, and in the Mine of the Future
- Mining Wireless Broadband
- Bringing the Revolution Down to Earth
- Where to From Here?

DEEP FAULT LINES – INDUSTRY CHALLENGES

The price shocks experienced in recent years have forced mining to confront historical issues with productivity, people, security, and companies'commercial agility:

- **Escalating safety regulation compliance costs**
  Greater workplace health and safety issues persist at mines and processing facilities despite increasingly strict regulation.
- **Environmental regulation**
  Mine operations are monitored for emissions, contamination, waste and pollution. Environmentally-sound site restoration is now part of the processes and costs of mine closure.
- **Declining ore grades**
  As high-grade deposits are depleted, lower grades are processed at greater cost.
- **Increasingly expensive exploration**
  Superior quality deposits are harder to locate and develop. Potential sites include the sea floor, deeper underground, and remote regions.

  In a paper outlining Finnish mineral strategy (2010), Professor of Mineral Economics at Luleå University of Technology, Magnus Ericsson states that explorations may have just a one in four hundred chance of becoming a commercial mine. Others cite even more pessimistic figures.
- **Shrinking workforce and widening skill gaps**
  The current skilled workforce is ageing and there is resistance from younger workers to mining as a career. Employee turnover is up to 30% in remote locations.
- **Growing threat of cyber attack**
  Insecure legacy communications and industrial control systems are increasingly vulnerable to cyber attack.
- **Decreasing ability to respond to increasing market volatility**
  Businesses are unable to adjust to rapid change in supply, demand, or pricing.

Underlying these issues is a deeper problem: a business model that is no longer in step with the market. According to an IBM white paper, “many miners believe nothing can be changed: you have a mine, a railway system, a nearby port and that is it.” (from ‘Envisioning the Future of Mining’ (2009)). This model understands the role of mining as delivering large volumes of product as cheaply as possible. Operations and staff at individual mine sites have no means of managing operations remotely, collaborating with staff at other sites, or optimizing operations in response to changing demand or market conditions.

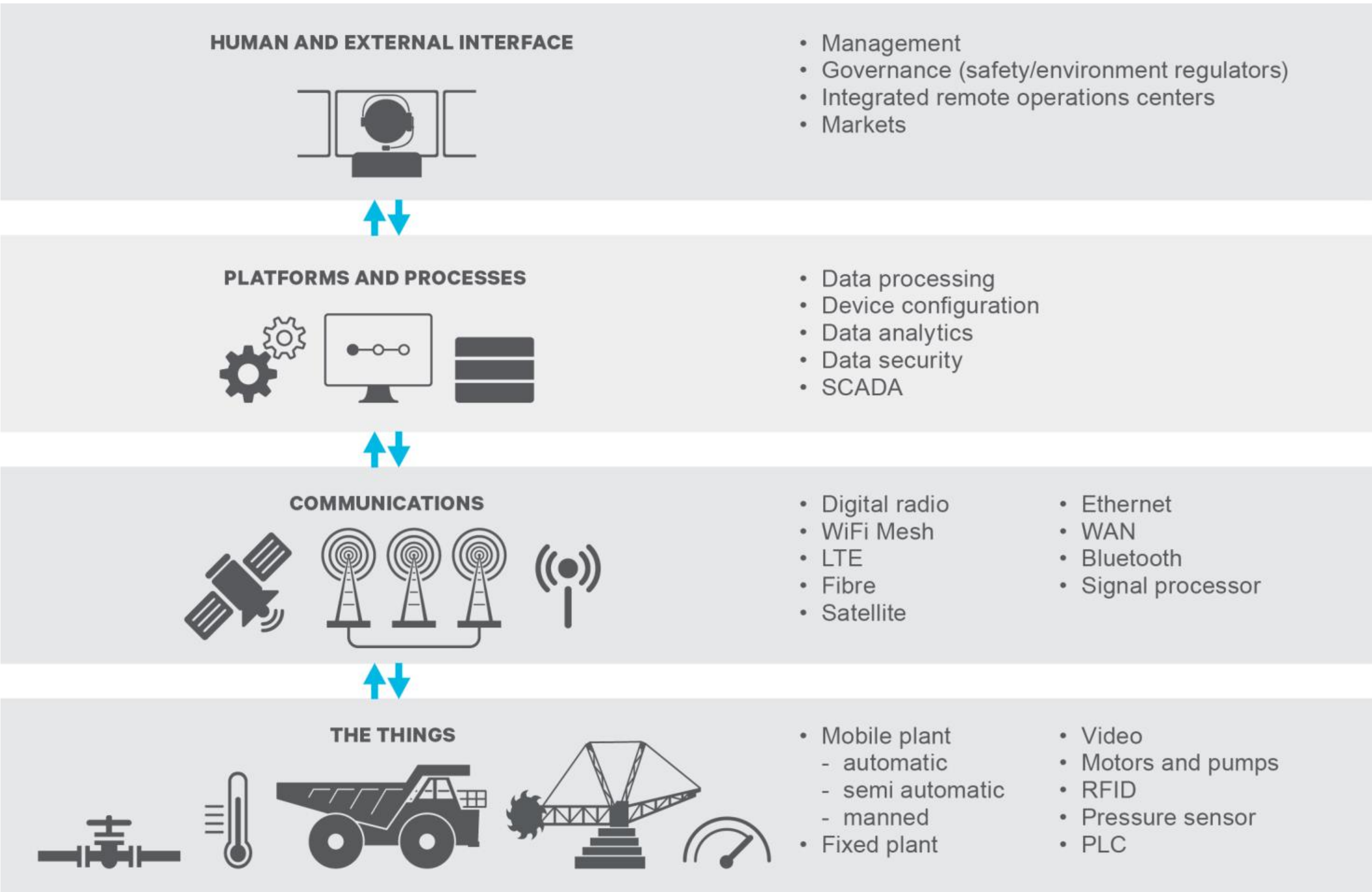
This kind of flexibility requires an altogether different mindset, an adaptable organization, and the tools and data to support a change of direction.

PROSPECTING FOR NEW SOLUTIONS

The digital revolution in communications, IT, and automation technology has opened possibilities that industry leaders are adapting to mining. In some aspects, other industries are further down this road: Oil and Gas with its ‘Digital Oil Field’, and Utilities with its ‘Smart Grid’.

These models are leveraging the convergence of IT, digital telecommunications, IP networking, and the Internet of Things (IoT) to integrate, automate, and optimize mining operations. Physical devices communicate directly – machine to machine - without human intervention. Sensors, measuring devices, and actuators embedded in field equipment can exchange data in real time, so they can be monitored, integrated, configured, optimized, and managed remotely (or manage themselves).

Connected by integrated wireless networks, purpose-built applications now send combined and integrated data to servers for storage, retrieval, processing and analysis. With potentially millions of smart elements sending real-time data 24/7, datasets and data flow can be huge.



By processing field data continuously in real time, applications automate decision-making, perform predictive analyses, react to alarms, monitoring and controlling operations from pit to port. Meanwhile, control room personnel see and interact with a virtual representation of a field (or site) and all its components.

Opportunities include:

- SCADA networks that directly manage process systems by controlling fixed plant,
- real-time CCTV or drone surveillance of production performance, tailings, ore passes etc,
- surface-controlled sensors continuously monitor and respond to underground conditions,
- real time slope monitoring detects and measures physical changes to manage risk to equipment and personnel,
- collecting and analysing equipment status and performance to predict and respond to equipment faults before they impact production,
- on-site staff and off-site experts collaborate via voice, data, and real-time video, to improve the quality and speed of decision-making,
- managing historical data and workflow analyses creates standard 'best company practice' workflows for teams that monitor, operate, develop and maintain a mine, freeing up engineers from this responsibility,
- standardized production data, workforce rosters, and production allocations for accurate forecasting and efficient real-time decision-making,
- integrating representations of the mine sites, production, injection network, wells, economics and planning tools, modelling the entire field so operators can optimize production across multiple sites, optimize the entire supply chain, and run analyses and forecasts in near real time.

These opportunities mean that a mining company can manage any field or site digitally, largely automatically — even fully remotely.

"By processing field data continuously in real-time, applications automate decision-making, perform predictive analyses, react to alarms, monitoring and controlling operations from pit to port."

DEVELOPING THE MINE OF THE FUTURE TODAY

The benefits that every mining company seeks are consistent across the industry:

- better workplace health and safety
- better environmental sustainability
- improved productivity and reduced operational cost
- skilled staff deployed more efficiently
- increased integration across business operations.

Using the Smart Grid and Digital Oilfield as examples, mining companies see that a digital transformation can deliver these benefits. Common to all smart mine initiatives are specialized automation solutions, using their new-found ability to move and process enormous amounts of information rapidly, to integrate operations across the entire range of business activities.

For example, since 2008 Australian mining giant Rio Tinto has been developing its own four-part 'Mine of the Future' programme:

1. **Operations Centre**
   From a single location in Perth, all Rio Tinto's mines, ports and rail systems can be operated remotely 24/7. Visualization and collaboration tools provide real-time information across the demand chain.
2. **Autonomous haulage systems**
   A fleet of Komatsu autonomous trucks at Pilbara mine allows more material to be moved efficiently and safely, directly increasing productivity.
3. **Automated drilling systems (ADS)**
   Trialled at Rio Tinto's West Angelas mine prior to deployment across Rio Tinto's Pilbara operations.
4. **AutoHaul**
   Several kilometres long, these heavy-haul, long distance trains generally require specialized, scarce, and expensive drivers. A driverless rail system will provide additional capacity without additional trains.

Even where benefits are not directly business-related, there can still be commercial advantage. For instance, Vale's S11D project pioneered a dry processing treatment using the high natural moisture content of the local iron ore. Not only is this more environmentally sustainable, it also reduces water consumption by 93%, driving costs down by eliminating the need for tailings dams.

RECENT DEVELOPMENTS

- **In 2017, BHP Billiton introduced Caterpillar autonomous trucks at its Jimblebar iron ore mine, adding autonomous drills to improve safety, increase productivity, and cut drill maintenance. Within a year, the company reported a subsequent overall cost reduction of 20%. Their website states plans are being drawn up for more radical developments, including autonomous trains to carry ore to ports and unmanned 'ghost' ships to transport processed product.**
- **FMG plans to convert more of its Pilbara iron ore haulage to driverless trucks to trim costs.**
- **In Brazil, the world's largest producer of iron ore and nickel, Vale S. A., invested $14.3 billion to develop its S11D Eliezer Batista Complex. The mine features an entirely truckless system of mobile excavators and crushers interconnected by over 68 kilometres of automated conveyor belt. This is expected to slash fuel costs by 70% and significantly reduce waste and emissions.**
- **Barrick Gold is trialling an ambitious surface-based Wi-Fi-connected tele-remote system to pilot underground loading vehicles at Cortez Hills mine in Nevada. Aimed at removing workers from stressful, dirty, and dangerous underground loading operations, trials appear to eliminate operator fatigue, remove shift handovers (60 to 90 minutes per shift), and reduce wear and tear on machinery. Plans include autonomous drilling rigs and remotely-operated underground haul trucks to work with new loaders.**
- **Swedish mine operator Boliden's Kankberg gold mine is in the process of becoming fully automated. Installing reliable digital communications in the complex network of underground caves and tunnels was technically challenging but subsequent automation has exceeded expectations in terms of both safety and productivity. However, their experience highlighted a need for standardization before this approach can be widely adopted.**

COMMUNICATIONS NOW, AND IN THE MINE OF THE FUTURE

Always critical to mining, communications requirements continue to increase. As communication technologies continue to evolve, mines employ a disparate mix:

- **Wired:** phones, bell-signaling systems, paging phone, carrier-current, fiber optical.
- **Semi-wireless:** leaky feeder systems, location and monitoring for personal safety system (LAMPS), cordless phones, VoIP phones via Ethernet.
- **Through-the-Earth (TTE):** underground communications- using Very Low Frequency (VLF) or Ultra Low Frequency (ULF) transmission and digital audio compression. Popular Personal Emergency Devices (PED) provide fully wireless text-only communications.
- **Wireless:** including LMR radio, pocket pagers, 3G and 4G cellular, WiFi mesh networks, Bluetooth, WiMax, RFID, tracker tagging and Ultra Wide Band systems.

This diversity reflects both the history of mining and the extent of its communications requirements. Above ground, LMR remains popular for voice communications because it is highly reliable, has excellent coverage, SMS data capability and is largely cost effective. Below ground, LMR communicates via leaky feeders. Existing industrial monitoring and control systems use purpose-built sensors and other proprietary components. Above and below ground, wireless data is commonly communicated over WiFi mesh systems.

"…it is unlikely that any single technology can serve the complex needs of the mine of the future."

But change is coming. Communications that will improve safety, enhance monitoring, and increase automation and remote control are driving solutions that offer massive data throughput and significantly lower latency. Innovation will undoubtedly influence the mix of technologies deployed, but it is unlikely that any single technology can serve the complex needs of the mine of the future.

Here's what mining operations of all sizes are likely to encounter in the future:

"The mine of the future will continue to utilize a mixture of communication technologies."

To integrate their operations, companies must also integrate the communications that coordinate them. While no one expects a single, seamless system to combine all current technologies, it is possible to unify several of them, because most modern communications technologies are digital, designed to run and be managed within an IP-based infrastructure.

Today's mining communications are usually geographically constrained around individual mines. However, the mine of the future demands integrated company-wide communications across the entire reach of operations – not just from pit to port – across multiple field sites, and city-based corporate offices. Backhaul options to transport the traffic required for remote automated operations include satellite, fiber and wireless such as microwave, 4G/5G cellular, and MIMO (Multiple-Input Multiple-Output). Large companies are considering a variety of communications to achieve this wide-ranging coverage. The integration of mining communications will require backhaul to match the company's coverage, latency, and capacity requirements.

"The mine of the future will integrate diverse communications with unified management to form a single, converged network."

"The mine of the future demands new communications requirements not envisioned when today's systems were designed."

Remote monitoring and control means that smart sensors will dump huge quantities of data (in near real time) onto networks. Sensor analytics applications can statistically process and feed them into Big Data analytics. Operational management (or machines) will act on the results to track mine performance, alter schedules, modify operations etc.

In short:

"The mine of the future will rely on an integrated, wide area, heterogeneous communications system that can support high speed, high bandwidth, low latency voice and data – all while remaining mission critical."

MINING WIRELESS BROADBAND

Little wonder then, that companies trialling smart mine programs are investing first in upgrading their communications systems. Mines are installing large-scale 4G LTE wireless broadband networks, using the same digital communications technology that powers today's 4G cellular phone systems. LTE offers many features for the mine of the future: high data capacity, low latency, excellent resilience, and exceptional spectrum usage. In particular, LTE can handle diverse data demands (e.g. field reporting, dispatching) and can prioritize traffic based on Quality of Service (QoS).

"… companies trialling smart mine programs are investing heavily in upgrading their communications systems."

However, LTE cannot do everything. Individual cell coverage areas are small compared with LMR, requiring many more towers to achieve the same coverage. If coverage is required over a large geographical, and/or complex topographical area, data performance may be a brilliant 150 Mbps next to a tower, but may drop off rapidly to a miserly 0.25 Mbps as an LTE terminal user moves to the cell boundary. Unlike LMR, throughput can vary, depending on network loading at any given time; when network traffic is especially heavy (e.g. during an emergency) some applications may fail altogether. As public safety users have found, it is a good idea to pair LTE with LMR, to guarantee coverage and to provide redundancy for mission critical applications.

LTE, of course, is not the only wireless broadband technology on offer. Oil & Gas invested initially in WiMAX, another packet-based all-IP technology. WiMAX is built on the IEEE 802.16 suite of wide-area communications standards and can achieve coverage, data rates and latency comparable to LTE, yet is considerably less expensive to deploy. However, the chief advantages that LTE has over WiMAX are:

- 4G LTE is compatible with most previous 2G and 3G mobile communications technologies (e.g. GSM/EDGE, GPRS, UMTS/HSPA, 3GPP etc).
- LTE tolerates faster-moving mobile users (e.g. high-speed trains).
- LTE consumes less battery power for uplink communications from mobile terminals.

As a result, LTE has won over all the major mobile phone companies, which has also influenced some in the industry to opt for LTE. LMR manufacturers have also come on board, with products (including intrinsically-safe subscriber units) that support digital LMR (P25, DMR, TETRA) as well as LTE.

In the future, 5G will offer a significant upgrade from 4G LTE with even greater capacity, and dramatically lower latency. However, coverage will suffer further.

Either LTE or WiMAX could potentially replace the WiFi mesh networks that currently provide wireless data communications above and below ground. Mesh networks pass data from one device to another, so two devices that are too far apart can still exchange data via a chain of intermediate devices. This pass-the-parcel technique works well when devices talk frequently to their WiFi neighbors (e.g. sensor networks), and when many are clustered in the same location. But each device must be within range of its nearest neighbour, and performance obviously depends on length of the chain connecting any two devices; longer chains mean slower connections.

But while many underground wireless data comms currently use WiFi , this could change with automation. If, say, seven or eight emergency generators all need to communicate to an operations center at the same time, rather than to each other, then wide-area cellular, (LTE or WiMAX) is worth the extra cost.

Competing standards LTE-M and NB-IoT allow low-powered and less-expensive devices (such as battery-powered sensors) to operate on standard cellular networks, thus bringing cellular underground. The frontrunner LTE-M is essentially LTE lite – since it can use the same spectrum and infrastructure as standard LTE, and works wherever LTE works - including support for TCP-IP data sessions. NB-IoT can operate over LTE carriers once it is enabled on the network, and offers similar energy efficiency - devices that run off the same battery charge for years, instead of days.

BRINGING THE REVOLUTION DOWN TO EARTH

The smart mine revolution will impact every diversified mining company. The pressure to maintain competitiveness reaches from the international giants down to medium and small mine sites. If those large scale digital transformation programs cut costs appreciably, improve productivity, and achieve good profitability in current market conditions and pricing, then everyone else must follow suit or be left behind. But clearly, they demand a massive budget and an appetite for risk that not everyone can afford.

Does this mean that smaller mining companies are doomed to forego the benefits of this industry revolution? Plainly, the answer is 'no'. For example, while driverless rail haulage may be out of reach, autonomous drilling rigs may not be, particularly if prices drop as they become more widely established.

There are opportunities for every company, whatever its size. The smart mine programs of the largest miners provide tests, lessons, and options for everyone else to pick and choose from. These programs can demonstrate:

- what risks must be accepted, and what costs will be incurred,
- what is possible now, and how it may evolve,
- how to migrate to new technologies,
- how well it works,
- what company-specific development is necessary.

"…any mining company can scale each part of this strategy to its own operations. The trick is to start somewhere."

It is the strategy behind smart mine programs that hold the most important lessons, since any mining company can scale any part of this strategy to its own operations at its own pace. The trick is to start somewhere. For instance:

- automation could replace some human-assisted drilling rigs with fully-autonomous rigs.
- camera-equipped UAVs could assist exploration.
- basic remote operation could utilize existing equipment. For example, pumps, ventilation fans or generators can be controlled remotely using LMR data on a network that is normally relegated to voice-only communication.

WHERE TO FROM HERE?

Integrating communications is a major enabler of integrated mine operations and developing better automation solutions.

The most important initial step is to upgrade mining communications with an eye towards future integration and better data capacity. IP-oriented digital technologies, have better connectivity and are easier to integrate into a single, converged network system using multiple technologies with integrated management. So, a goal of upgrading existing communications should be to gradually replace any technology and equipment that is difficult to integrate. One target might be SCADA systems that still use proprietary protocols and components. Equipment that uses open standard protocols or application programming interfaces (APIs) is not only easier to integrate, it also avoids single-sourcing, and future-proofs both the equipment and the system for future integration with additional components.

"Equipment that uses open standard protocols or application programming interfaces (APIs) is not only easier to integrate, it also avoids single-sourcing, and future-proofs both the equipment and the system for future integration with additional components."

There are no ready-made solutions for integrated mining, which is why the current smart mine programs all started from experimental pilot projects. However, a proven strategy for mitigating innovation risk is to develop key partnerships:

- Vale's clever automated conveyer system was the result of a partnership with Canadian firm Rail-Veyor Technologies Global Inc.
- Boliden's automated gold mine is a result of multiple partnerships, including Ericsson (communications), Volvo (autonomous vehicles), ABB (ventilation systems) and Sandvik (underground mining equipment).
- Barrick has partnered with Cisco to digitize its operations, utilizing both predictive data and analytics and real-time data to increase efficiency, productivity and safety.
- Rio Tinto's AHS driverless truck project was largely due to its strong partnership with Komatsu, which supplied the trucks and co-developed proprietary technology to enable the trucks to run autonomously.
- BHP built its driverless truck system with US equipment giant Caterpillar.

Good partnerships can accelerate development - and distribute both risk and cost - for any part of a smart mine strategy for any mining company. These strategies will advance digital transformation, upgrade and integrating existing communications, build automated equipment systems, or work out how to exploit the wealth of information generated by the new mining technology.

The mine of the Future may have been introduced by the industry giants, but these examples demonstrate in practical terms how technology can safeguard the future of an entire industry. In every instance, their solutions sit across robust, reliable, multi-platform communications that are integrated across the entire operation. By upgrading your communications for future integration and greater data capacity, you take the crucial first step.

"Start now!"

ABOUT THE AUTHOR:

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