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Underground mining readies for the IIoT revolution

Industrial Internet of Things (IIoT) technologies that can seamlessly connect vehicles, machinery and personnel in even the world's deepest mines promise a new era of safety, productivity and profitability for underground mining.

IIoT systems will offer comprehensive oversight over underground fleets, personnel and equipment

Communications infrastructure, positioning tools and sensors are seeing rapid advances, bringing the underground mine of the future much closer. Aided by Artificial Intelligence, data processing systems are growing powerful enough to crunch the vast data streams being generated.

But considerable challenges remain - establishing wireless communication networks across shafts and stopes underground is difficult and expensive. Repeated blasting can damage expensive IIoT devices, and drilling constantly changes the layout of underground operations.

Industry experts say the first important step towards the connected underground mine of the future will be more stable connectivity, as this is a precursor to the introduction of smarter sensor networks, more automation and better operations management and positioning systems.

Connectivity is key

"The biggest challenge related to IIoT in the underground mining environment has always been connectivity", said Mike Jackson, president and chief executive of South Africa-based technology systems integrator Ramjack.

"But advances in communication technology are helping to solve critical issues that have affected us in the past, such as losing access after instruments have been deployed, or not getting readings on a regular basis."

Other industry experts agree that communications advances will be the criticalk enabler of emerging sensor and edge-computing technologies.

"It has been a challenge over the years for underground mines around the world to adopt more modern communication infrastructures, mostly because of the costs of deployment and maintenance," said Cynthia Younes, head of marketing and communications at Quebecbased underground mining technology and systems company Newtrax.

"But more modern and advanced communication infrastructures are now helping the adoption of IoT solutions into underground mines. These are enabling mine managers and other personnel to not only see, but also gain a deep understanding of, what is happening underground in near real-time," said Younes.

Andrew Clark, a product manager from the Swedish mining technology firm Hexagon, said a ramp-up in investment in new communications technologies is needed to increase autonomous solutions.

"All the exciting new IIoT technologies we are seeing will require systematic infrastructure advancements to accommodate the increase in data transfer, particularly when planning for an autonomous-heavy future."

"But thankfully the industry has been investing heavily in the progression of 3/4G LTE networks, and more ruggedised, fit-for-purpose WiFi systems will make new features an accessible reality."

Real-time connectivity

Emerging communications solutions include a real-time connectivity system for underground mining that Canadian mining-focused data management firm Symboticware is developing with Finnish telecommunications technology company Nokia.

The networking system, which combines Symboticware's telemetry technology with wireless capabilities developed by Nokia, can support more advanced machine-to-machine protocols that use artificial intelligence and machine learning.

This is possible because Nokia's industrial-grade wireless connectivity solution does not rely on WiFi, which lacks the low latency and reliability required for supporting nextgeneration IIoT applications.

"The Nokia and Symboticware collaboration will help to move AI and machine learning forward, which are capabilities that will play a major role in the future of this industry," said Kirk Petroski, Symboticware founder and chairman of the board. "This is a solid development in the area of underground operations."

The Nokia and Symboticware solution is already being used at the NORCAT Underground research centre in Sudbury, Ontario and will be available on the market in 2021, said the companies.

Smarter sensors

Ramjack's Jackson noted that while many of the sensors that will be connected by emerging IIoT system have existed in analogue forms for years, that digitising them

and giving them the ability to communicate reliably and affordably, will be transformative for underground operations.

"Monitoring instruments have been in use for decades, but getting - and keeping - connectivity to these instruments has always been difficult." The development of persistent sensor networks using battery-powered devices is as "game-changing" for underground mines as signal propagation for WiFi, mesh and LTE technology, he said.

He said the advent of persistent sensor networks - unattended sensors that work continuously - has been powerful, because these can run on batteries which last for years, constantly logging data and communicating wirelessly over a long distance via point-to-point or meshing. "This has virtually solved the challenge of connecting to instruments for regular and real-time data capturing," noted Jackson.

Symboticware's SymBot, the sensor network interface for Symboticware's data collection platform, was originally developed for underground mines. It collects data from sensors, stores timestamped data into an internal database and, using Symboticware's "store-and-forward" technology, transmits the data over existing infrastructure to SymView, a centralised server and data aggregator.

IIoT in mine design

Improved laser mapping systems connected to IIoT systems re also expected to streamline mine designs and activity-based schedules.

Hexagon's Clark noted that the increased adoption of LiDAR capture and processing units better suited to underground operations are having a major impact.

These technologies give "individual assets both the image capability and computational power to quickly and accurately map heading and stope excavation," said Clark, who is product manager for the company's MineOperate solution.

"Safety is also benefiting from the progress in underground IIoT, with the widespread adoption of in-cab operator awareness systems being used to combat fatigue, assist in evacuations and monitor health diagnostics, through wearables."

Location, location, location

Ramjack's Jackson noted that another of the critical technologies enabled by better connectivity are positioning solutions being developed for location tracking in GNSS-deprived environments.

"BLE [Bluetooth Low Energy] and UWB [Ultra-wideband] technologies are being adopted in underground environments for easy and affordable location tracking, and it is now also possible to use synthetic GNSS signals for satellite tracking in underground mines just as was done for decades on the surface", said Jackson.

In July, Ramjack Technology Solutions announced a partnership with Syntony GNSS that will see the companies deliver the underground GPS Coverage Extension solution SubWAVE.

Jackson noted that using his mobile phone, and the Syntony technology, he was able to track his location underground in real-time using Google Maps to less than two meters accuracy.

"This is a truly amazing innovation that will forever change the way underground mines use technology," he said. "The need for accurate underground tracking — and the convenience of being able to use the industry-standard GPS chipsets — is a huge advantage and one that we've been waiting for in mining for a very long time."

AI's bright future

Industry experts say fully automated, continuous underground mining systems of the future will also require advances in the use of AI and advanced analytics to process the terabytes of data involved, but that the benefits will be wide-ranging.

"Putting the data to work underground will open up new frontiers in many disciplines. For Geotechnical Monitoring, for instance, AI and advanced analytics can offer invaluable insight in pre- and post-advance scanning," said Hexagon's Clark.

"Using these technologies, we can monitor changes in rock stress, analyse precise shifts in movement thereby leading the way to predict possible future failures. Similarly, when looking at rock fragmentation analytics, concise feedback of big data back to the drill and blast modelling/planning cycle can result in minimizing further overbreak and/or controlling blasted fragment size in stopes and headings."

Ramjack's Jackson said there are "huge opportunities" in mining to take advantage of AI and advanced analytics.

Putting data to work underground will open up new frontiers in many disciplines - Hexagon

"The vast amounts of data being gathered by the instruments in the field are, in many respects, not being fully utilised. Through persistent sensor networks and real-time alarm handling, IoT solutions have already provided tremendous ROIs to many mines across the globe. The advancement of Remote Operations Centres has helped ensure that mines realize the true value of the real-time technology they've deployed."

Jackson, whose company offers remote operations centre and artificial intelligence analysis services, noted that using AI to analyse data is the next important step.

"AI takes the advantages of IoT to the next level by ensuring mines can realise the true value from their big data sets. Combining Remote Operations Centres with artificial intelligence and machine learning capabilities combines the value of being able to make great immediate decisions using real-time data with being able to make great long term business improvements through the analysis of big data sets."

Newtrax's Younes said that advanced analytics and AI will "provide underground miners with the ability to measure and compare productivity data that were never available before".

Standardising measurement

"It will be possible to standardise productivity measurement across operations, and allow mining companies to optimise the mining process as a whole from stope to mill, rather than having separate initiatives."

"By using all the historical data collected and processed, underground mines will become much more "predictable", which will increase plan adherence as well as increase safety by reducing unknowns and surprises," she added.

Hexagon's Clark noted that the predictive technology enabled by AI and advance analytic make underground mines safer and more productive, particularly for real-time traffic management, noting that this is another example of applying what has been learnt on the surface into the underground environment.

"Analysing the position and destination of the fleet can lead to managed routes that minimise congestion at known bottlenecks and travelways and optimise the load and haul cycle across multiple draw points and stockpiles," he said.

Machine health is another area that can benefit from a more connected mine, with advanced diagnostics being able to read from an ecosystem of sensors to minimise parts failure through learnt prediction, said Clark.

All together now

Future IIoT systems will aim to offer a more comprehensive oversight over underground operations, in contrast to the siloed IIoT tools of today, which are often developed for specific applications such as ventilation monitoring or fleet management.

"IoT systems integration remains a challenge today for many reasons including closed architectures, unsynchronized timestamping of sensor data and inconsistent data labelling," said Younes.

"But the fusion of tracking, telemetry and proximity data streams from the underground extraction process combined with visualisation of this data on 3D underground mine maps has the potential to empower workers with unprecedented levels of insights."

Existing solutions are starting to consolidate data streams. Newtrax has developed the IoT Hub, a data aggregation platform that can connect all IoT devices into a single data repository. The IoT Hub connects datasets and information in real-time with any choice of software applications via API, enabling transparency of mining processes.

MineOperate UG Pro

Hexagon's MineOperate UG Pro monitors activities at task level, updating miner and machine workflows in real-time as the mine develops and produces ore. Developed specifically for mines lacking data networks underground, UG Pro uses tablets that store and forward critical information between supervisors and workers via network access points.

Ramjack's Jackson noted that while new platforms will consolidate data streams and various solutions, the development of certain technologies in a "silo" is not necessarily a negative.

"Many of the operational and safety challenges that miners face are different to those in other industries, therefore the solutions to those challenges often arise via innovation within the industry - new ideas from small companies or experts in their specialised field. This results in technologies being developed to solve specific problems, not necessarily with the entire mining value chain in mind."

"This is a fascinating phenomenon and it is actually a good thing. Small companies and experts are better suited to solve the specific needs of a specific component of the solution."