The Interoperability Advantage: How Mining Can Gain from Open Platform Technologies

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OVERVIEW

The integration of information technology into regular business processes has proven transformative for the mining industry in the 21st century. Yet, the current prevalence of siloed systems hampers the industry's potential for growth and its ability to take full advantage of emerging technologies for further productivity and efficiency. To implement Big Data, IoT, and autonomous vehicle platforms into mining processes effectively, mining corporations must develop systems and workflows to facilitate discrete technologies working interoperably.

This paper presents an overview of the current state of technological interoperability across the mining industry, then highlights opportunities for improvement available through its maturation. With a clearly defined vision of robust interoperability in mining, this paper then details current systems and methods available to bring this vision to fruition.

OPPORTUNITIES IN MINING THROUGH INCREASED ADOPTION OF INTEROPERABLE TECHNOLOGIES

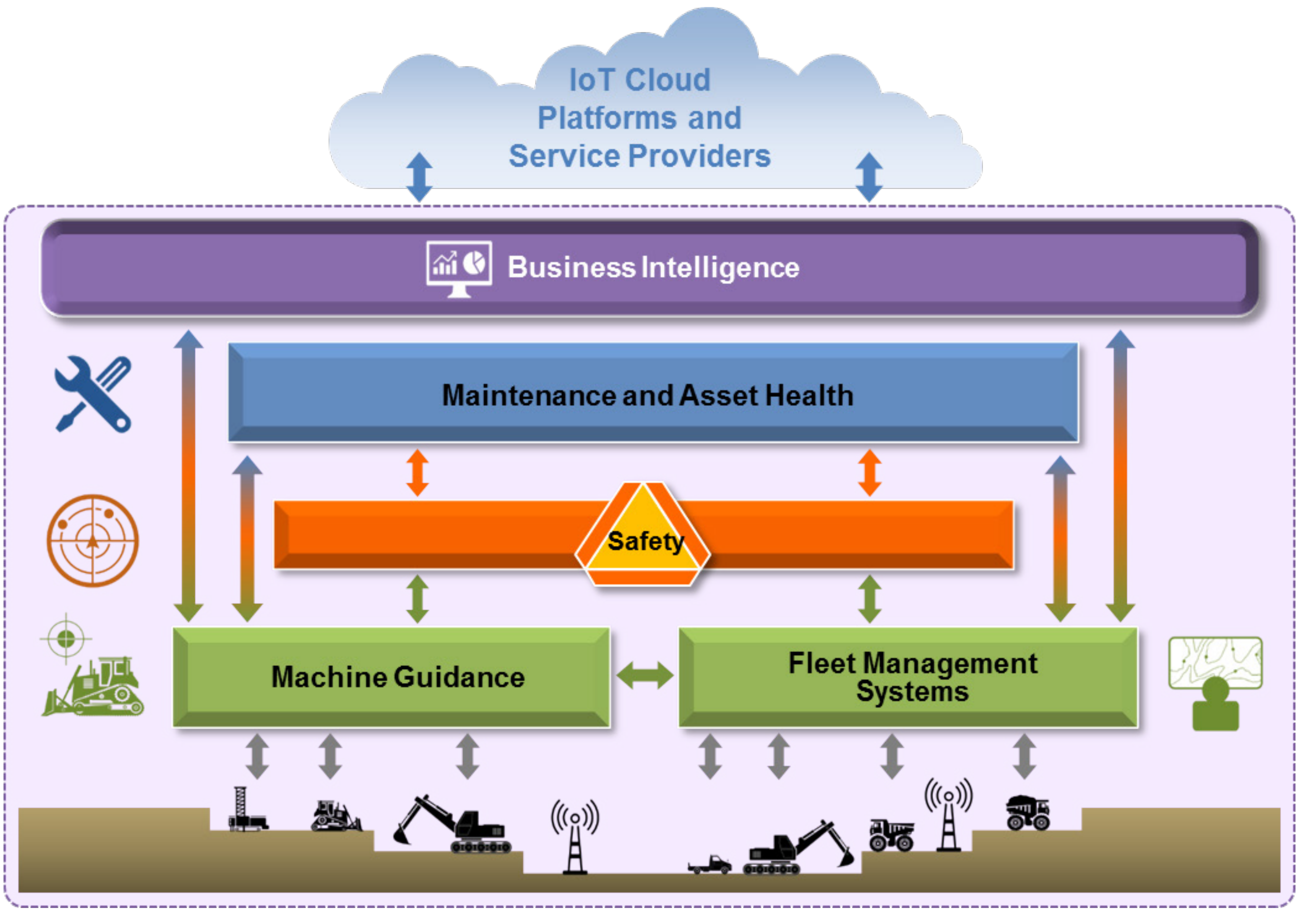
The rise of data collection and processing technologies in the 21st century has transformed mining, as it has many industries. Large and small operations alike have readily adopted data systems to manage fleet dispatching, track geological composition of lease holdings, monitor plant production, and handle other duties required to maintain an active site. This rate of technological penetration mirrors the spread of data systems in such diverse fields as finance, agriculture, retail, and manufacturing, among others. Indeed, any industry that follows cyclical trends and requires associated forecasting has rapidly grasped the advantage these technologies can provide for strengthening standard operating procedures and other business processes.

Yet, in many respects, the similarities between mining technology and other industrial systems end there. While domains as varied as agriculture, manufacturing, and finance have successfully incorporated technological protocols and standards that enhance the portability of data, open platforms have yet to see the same penetration in the mining industry. As of Q3 2018, market-leading data systems across several subdisciplines of mining function using proprietary infrastructure that heavily restricts end-user customization, configuration, and connectivity.

In previous decades, these proprietary systems served industry needs well. From the 1980s through the 2000s, mining operations made significant gains in productivity and efficiency using data technologies, even as they worked in silos. However, in recent years, a debate has circled among today's mining leaders: Can these systems offer any further advancements while they remain under a closed architecture? Have these discrete systems reached the threshold of their potential value without adding data interoperability functions?

In 2018, the Global Mining Standards and Guidelines Group (GMSG) identified interoperability as a priority industry initiative. Mining operators routinely voice concerns about OEM restrictions that impede their ability to use their purchased systems interoperably with one another. But, through forced adherence to single-vendor ecosystems by a lack of data interoperability, mining operations are unable to automate processes through open standards, use best-of-breed technologies to advance performance, or take advantage of emerging technologies with the potential to wholly transform standard operating procedures — including Big Data, IoT, and autonomous vehicles.

To advance to the next level of productivity and efficiency, the strongest potential rests in making mining data systems work interoperably. As Fraser states in his paper, "The Intelligent Mine: Next Generation Technologies and the Need for Interoperability": "Companies are now realizing that with the availability of improved communications, automated systems, and our ability to 'sensor up' nearly any process or activity, significant productivity gains could be attained by integrating information from across the value chain" (Fraser 2015). Therefore, an ideal suite of technology for the mining industry is one that supports mines in using the full range of solutions of their choice. Widespread adoption of open architecture would afford mines the ability to configure their selected solutions to work interoperably, allowing for fluid automation of processes now and creating an environment to implement leading-edge technologies as they become available in the future.



The above diagram proposes one vision for an interoperable suite of mining solutions. At the pit level, fleet management and machine guidance systems interface with each other and various onboard OEM and third-party systems. Working interoperably, these systems can share data to govern the activities of each equipment unit and of the fleet as a whole. Safety solutions can then leverage this data in addition to their own to make split-second decisions that enhance operator and equipment security. Interoperability also allows maintenance and asset health solutions to use all of this data to improve assessments of machine components and predict their performance trends with greater accuracy. Business intelligence platforms can then search all of this operational data to discover connections and correlations human analysts may miss, presenting them as clear, actionable information. In this vision, interoperability allows these benefits to extend beyond an individual site, connecting with other operations, IoT platforms, and external service providers in the cloud for rapid control and insight of an entire mining enterprise.

THE CURRENT STATE OF TECHNOLOGICAL INTEROPERABILITY IN MINING

While industries such as retail, finance, and manufacturing have emphasized interoperable technologies, mining has placed less weight on such system features thus far. The unique nature of mining may explain why interoperability receives more attention in other industries. In contrast to other sectors, mining involves distinct factors that may interfere with multilateral cooperation toward greater technological interoperability.

Mining tends to exercise stronger caution than other industries with respect to new technologies. Although mining companies have eagerly adopted technologies that facilitate robust performance in extraction, energy usage, environmental sustainability, and safety, they do so with keen discretion (Thompson 2015). Mining maintains higher upfront costs than other industries. Unlike retail or even manufacturing, mining requires much greater initial investment, lead time, and financial risk. From primary exploration through construction and commissioning, even well-funded mining companies must wait for extended periods before seeing any return on investment. Therefore, many mines require substantial proof of capabilities prior to experimenting with new technologies. As such, researchers and vendors may struggle to make headway as they seek to implement novel systems.

This risk profile affects mining investment in other ways, as well. Only certain operators maintain the capital and risk tolerance to initiate complex mining projects, as opposed to the comparatively low-overhead ventures of retail or agriculture. In these scenarios, mining companies are especially judicious in granting partners and vendors access to their data. Often, mines form close relationships with technology providers who have independently engineered and still maintain established formats and protocols. These partnerships create a positive feedback loop in which technology partners have strong incentive and capital to engineer new solutions. This paradigm results in several major technology companies dominating the industry, each maintaining a full suite of mining solutions; open interoperability with third-party systems takes less precedence.

Of course, mines still find ways to use their preferred systems — they simply must expend undue effort and introduce opportunities for error that a truly interoperable suite of technology avoids. To synchronize data from various equipment OEMs, operating software, reporting software, contractor systems, and third-party peripherals without open standards and APIs, mines typically need to manually port data from system to system through neutral, intermediary formats. Unfortunately, this process involves significant amounts of time, human oversight, and opportunities for user error that drag down mine productivity and efficiency.

PROJECTED RESULTS OF IMPROVED INTEROPERABILITY

Beyond simply responding to such organizations as the GMSG, the mining industry can gain significant productivity, efficiency, and safety enhancements by increasing the depth of its technological interoperability. A fully interoperable suite of systems can address several persistent issues in mining, from technological bloat to siloed reporting to laying the groundwork for autonomous mining.

For instance, integrating the various systems used on mobile mining equipment can remove in-cab clutter and increase operator situational awareness. Most mining operations use a vast range of technology on their equipment fleet to monitor and control key aspects of their operation, including systems for fleet management, machine guidance, fatigue monitoring, tire pressure monitoring, fuel level detection, peer-to-peer safety, and more. When each of these systems is produced by a distinct vendor that favours closed architecture, each one requires its own computer hardware, cabling, screen, communication infrastructure, and installation components. Even inside the cab of the largest haul truck, the area available for these systems quickly becomes cluttered. Likewise, each additional screen forces further distraction on operators, who must contend with alarms and notifications from several devices that compete for attention. Frequent monitoring of multiple systems requires operators to take their eyes away from the road, interfering with their situational awareness and posing a legitimate safety hazard to the operator and any person or infrastructure nearby.

Integrating onboard systems can rectify these potential hazards, though. By leveraging systemic interoperability, a mine can select a core platform to serve as a clearing house, running all additional systems through it. In an ideal setup, all systems can operate using one hardware device and one display, removing the need for further physical devices mounted inside the vehicle. Based on the particular system configuration, this core system can then filter or prioritize notifications from any system throughout the onboard technological suite. For example, the Wencomine fleet management system (FMS) can serve in this clearing house role due to its central function in a mining operation and its ample selection of third-party interfaces. With these interfaces, mines can integrate their various onboard solutions into the system's Mobile Data Terminal (MDT) and allow each to show its data on an independent screen of the device's display. Information from each system then automatically appears as necessary, based on the FMS-derived equipment status (e.g., the MDT switches to a fueling screen to display data from a fuel level sensor when the FMS determines a unit has entered fueling status; a high tire temperature detected by a tire pressure monitoring system sends an alert to the MDT; etc.) In this way, mines continue to use all their chosen systems, but without unwanted disarray and distraction that interfere with efficiency and safety.

The principle of interoperability can provide strong value at the office level too. As with onboard systems, mines typically use a large number of desktop applications to plan, control, and analyze their operations (such as mine planning systems, ERP systems, plant control systems, reporting and analytics systems, and more). And, as with onboard technology, these applications typically work in silos, without free movement of data. Unfortunately, mine managers often need to correlate data between one system and another; to do so, they manually transfer information out of the operational software and into a neutral third-party format. This process greatly slows operational analysis and impedes automation. If these systems worked interoperably, a mining operation could synchronize these systems for more robust efficiency. For example, by connecting mine planning software with an ERP system and blast design software, a mine's production quotas could automatically inform the scope and design of upcoming blast patterns. Blasting software could then check the drilling consumables required for patterns against existing inventory. With appropriate business rules configured in the mine's supply chain, the system could automatically order any additional rods needed to complete drilling. This entire process could transpire in minutes, without any additional attention or input required from site personnel.

Even with these efficiency improvements, integrating onboard and office technology offers only a base level of systemic interoperability. Once the systems on each mobile unit and within the office work together effectively, an ideally interoperable system can commence uniting mobile data with office data. While many onboard systems actually include companion office applications, these components do not share data horizontally and, therefore, do not facilitate the advantages of true systemic interoperability. They merely allow site managers to collect operational data and monitor particular metrics, maintaining a need for heavy manual oversight. To gain the value of interoperability between onboard systems and office software, a central control system like an FMS becomes mandatory for funneling onboard data in a coherent way into office applications. Through an open FMS, onboard systems can automatically interact with office software. For example, a tire pressure monitoring system can sense a tire approaching its maximum work rate and inform the site's dispatching software, which automatically shifts that tire's unit to a shorter haul route that eases its stress load. This information can then populate an office-based reporting and analytics platform that assesses tire condition over time, associating it with particular operators, routes traveled, tire makes and models, and other parameters. A mine can then execute Big Data analysis and machine learning on this dataset to correlate particular factors that affect tire performance, ascertain cyclical trends in tire condition, and configure business rules that automatically optimize tire lifespan and overall mine productivity.

With the power of open architecture and contemporary data networks, this information is also no longer confined to a single, isolated mine site. Once all of a single site's data systems work interoperably, an international mining corporation can leverage cloud technology to synchronize data across multiple mine sites. A CTO can then explore operational data ranging from the pressure of an individual tire at one site to the company's global fuel usage over the last quarter and beyond. With optimal technological interoperability, key decision-makers can examine and understand business cycles, contrast them between discrete mine sites at distinct locations, and fluidly scale analysis to any desired level of detail — regardless of device manufacturer or system format.

This insight is unquestionably useful for making informed decisions. But, the strongest value of deep interoperability lies in making autonomous mining a reality. Machine learning and artificial intelligence are already starting to provide actionable benefits in optimization and predictive maintenance. These leading-edge technologies and others can greatly assist mining by making business decisions automatically with high degrees of speed and accuracy. To take advantage of these new powers, full technological interoperability throughout a suite of systems is a prerequisite. Data systems must be capable of communicating and sharing data with each other in order for true automation to transpire. By empowering today's data systems to work interoperably, mining innovators can set the foundation for the true digital mine — from exploration to excavation to extraction to refinement and distribution.

SYSTEMS AND METHODS FOR ACHIEVING INTEROPERABILITY

To move toward this vision of a fully interoperable mining operation, certain elements and principles must be in place. Most critically, parties involved with mining must choose to follow a philosophy of openness. In order for true interoperability to take hold, a mine's OEMs, technology vendors, peripheral manufacturers, and other stakeholders must prioritize the use of accepted industry standards and protocols that favour interoperability.

This interoperable approach requires a significant shift in thinking; still, other industries have managed to overcome this hurdle. Ultimately, an interoperable approach serves in the best interest of both mining customers and technology providers. Mines get to use any solution that best addresses their needs, while vendor engineers can dispense with managing and maintaining proprietary hardware and formats, instead devoting attention to assembling stronger market-driven solutions that an integration platform can put into action.

To further the advancement of this approach, industry associations and consortia can work to establish widely accepted standards that foster greater technological interoperability. In mining, the GMSG continues to work in this area, as do groups such as the Earth Moving Equipment Safety Round Table (EMESRT), the International Organization for Standardization (ISO), and the International Society of Automation (ISA). Standards like ISO/TC 73, ISO 15926, and ANSI/ISA 95 create mutual understanding and expectations that ensure adherents can interact in a coherent fashion, regardless of language, geography, system implementation, or other external factors.

With a commitment to interoperability and recognized standards in place, mining can begin to adopt many of the open technologies already in use in other industries. Component off-the-shelf (COTS) hardware provides a strong foundation for interoperability, as its buses, ports, and communications protocols natively conform to open standards. Likewise, use of existing open conventions and architectures — such as HTTP, XML, JSON, REST, and others — can greatly simplify the process of making systems work together. In systems that use these protocols and formats, any developer can freely create and implement new applications that fit into the overall suite, manipulating particular components to fulfill particular user needs. Such interfaces may range from a simple notification plugin to rich integration with a third-party reporting and analytics platform to full automation of OEM systems.

However, widespread adoption of these standards and technologies is still forthcoming. In the meantime, the mining industry can create an interoperable suite of technology by implementing an additional data layer that enables individual proprietary systems to interface with one another. For instance, Wenco International Mining Systems has created a Data Exchange Service that serves in this role. This multi-utility sits on top of the Wenco line of data systems, enabling any third-party data system to interface with Wenco products. The utility's public API allows popular machine guidance, crusher control systems, drill guidance systems, and more to read and write to the Wenco database and the Wenco system's real-time services. In effect, this API allows a third-party system to operate within the Wenco suite of solutions as though it were developed by Wenco. Equipment statuses, positions, operators, and events all write into the system through this channel. Users can freely implement any OEM machinery, peripheral, or supplementary data system they prefer, extending the utility of the Wenco system itself and removing the redundancy of maintaining multiple overlapping data systems. Although interoperability that exclusively subsists through this translation layer has limitations, it provides a practical means for the industry to achieve many of the conceptual benefits while acceptance of open standards remains out of reach.

USE CASE: BIN-LEVEL DISPATCH THROUGH CRUSHER CONTROL SYSTEM INTEGRATION

Certain mining operations are already receiving the benefits of strong systemic interoperability. At one study site in the American Iron Range, engineers successfully interfaced the mine's crusher control system with its Wenco dispatching utility. In doing so, this customer was able to maintain appropriate levels of material in its primary crusher bins, thereby facilitating steady throughput to the plant. At the same time, the interface logic conserved area within bins to allow for additional loads of material, enabling trucks to dump into them on a consistent basis instead of waiting for space to clear. In this way, the site was also able to significantly reduce haul truck idle times when dumping, raising per-unit efficiency and overall site productivity.

This particular site operates several crushers in its workflow, each of which feeds material for storage in multiple tiers of bins before transmission to the processing plant. Each bin stores a particular grade of ore. To maintain a steady flow of the appropriate ore blend to the plant, the site aims to preserve a constant amount of material in each bin. Taking advantage of its systems' potential for data interoperability, the site interfaced its Citect SCADA crusher control system with the Wencomine FMS through the Data Exchange Service. By sending real-time data through the Data Exchange Service, the FMS gained up-to-the-second knowledge of the remaining material volume in each bin, throughput rates, and operational status. With this data shared, the FMS dispatching algorithm is now able to rapidly update truck hauling assignments, redirecting vehicles to dump in crushers or stockpiles based on the particular downstream bin that needs material the most. Delay statuses or slowdowns in crusher throughputs can automatically trigger new dispatch assignments, so trucks can consistently make good use of payloads and hauling time. This functionality has proven highly effective at maintaining a steady flow of the appropriate blend to the plant, while also lowering wait times at crushers and raising utilization across the fleet.

This simple interface demonstrates just one level of interoperability on one site. An open API and widely adopted standards have the potential to extend this interoperability much further. Using an open utility such as the Data Exchange Service, this site can interface this bin level information to its ERP system to automatically update its production figures. It can integrate this information with a third-party business intelligence platform that uncovers further opportunities to optimize the crusher-dispatch workflow. It can synchronize its plant control system with real-time bin levels to maintain a regular flow within the plant as well. It can implement all of these system integrations and more to assemble a custom suite of solutions that brings greater value and ROI justifications.

CONCLUSION

Systemic interoperability is only anticipated to deepen throughout all industries in the coming years. Many leading-edge technologies such as IoT, autonomous vehicles, and machine learning rely on open standards and protocols in order to function. As consumer solutions like smart thermostats, self-driving cars, and predictive spam filters gain purchase in everyday life, heavy industry can only resist adoption of similar technologies for so long. With the obvious economic benefits and the pressure from the GMSG, EMESRT, and other prominent working groups, mining is slowly moving away from its silo-driven manual workflows and toward more open approaches for data handling.

Industry standards and open technologies have already proven worthwhile in sectors as diverse as agriculture, finance, and retail. In due time, the risk averse mining industry will doubtlessly follow suit. As evidenced from the study that integrated crusher control systems with Wencomine FMS dispatching services, user-developed customizations can offer exceptional value to customers who understand their needs in greater depth and detail than any external vendor. The potential benefits of wholesale technological interoperability are, legitimately, incalculable.

Yet, the most important issue is the future of mining technology. For modern mines to take advantage of advanced data systems, technological interoperability must be available and simple to achieve. Therefore, the mining companies with the greatest ability to leverage these forthcoming solutions need to prioritize data integrations, placing ease of interoperability at the centre of their suite of solutions and refusing proprietary formats and closed architectures as ineffective means of facilitating progress throughout the industry.

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