Tomorrow's mine
How digital can shape the future?
Executive summary

Globally, productivity remains the prime concern in the mining sector, particularly in the bulk commodities and use of digital technologies is a way to address this challenge. Digital is not just about incorporating a gamut of technologies but is an approach to run the mining business more effectively and sustainably. But there exists a major digital disconnect because of a range of practical issues such as scope definition, cost overrun, infrastructure etc. that continue to challenge the industry.

Use of digital in mining has slowly evolved with technologies such as, plant automation systems, Global Positioning Systems (GPS), mine planning systems etc. and recently to cloud computing. Significant benefits have already been realized but much more can be done with a holistic approach. The future is characterized as one where decision-makers (either human or automated) rapidly optimize decisions to maximize some objectives (operational/financial etc.). A mine of the future will be digital, with composite technologies spread but integrated across the value chain.

India has been a major participant of the global mining industry with a large resource base and has its unique set of risks and opportunities. While everybody agrees on the potential of mining in the country, it has been beset by political, judicial and regulatory interventions. Private exploration has been limited due to policy and financial constraints. Productivity continues to be a concern domestically and going ahead it will have a larger impact as open cast mines mature and finding ore bodies becomes complex. Infrastructure is a key for companies to grow and operate in remote locations efficiently. While globally, scale of mining favours large players and inherently reduces unit cost, India is plagued by small tenements and this hampers the ability of players to get large investments. While, all the participants are generally aware of the issues one of the efficient ways of addressing these challenges is employing smart digital solutions.

While digitalization is catching pace with big miners, it is not as yet a priority for the medium and small operators, who continue to deploy older technology and stick to conventional mining methods citing lack of cost-benefit visibility.

The technology domains that are relevant with use cases in mining include: IOT, Robotics, Big Data & Advanced Analytics, Mobility, CBM, Remote centre, AI, wearable technology, ore optimisation & quality, social media etc. Digital technologies offer a gamut of solutions and distinct benefits, but, it is employing the most relevant technology to the company’s business model that is most crucial. The entire solution package needs to be tailored to suit specific needs. Successful digital transformation isn’t limited to the technology in question, but is also a function of several factors that are critical for success, such as alignment with enterprise goals and overall strategy, enterprise-wide integrated architecture, technology enabled workforce, well-defined operating model and business case, clearly defined implementation pathway amongst others. It must also be noted that the culture to adopt innovation and willingness to change, flows from top-down.

Given the early stages of adoption in our country, the right approach to transformation is crucial. The industry does not need another cheerleader but requires a navigator in what is a difficult but highly prospective journey.
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Low commodity pricing, maturing mines and growing need to maintain competitiveness have shifted the average miner’s focus from targeting volume growth to achieving cost reduction and productivity growth. While miners continue to implement measures to drive productivity, the key to reinvention lies in the digital transformation of the industry. Digital is not just about incorporating a gamut of technologies but is an approach to run business processes more effectively and increase value.

There however exists a major digital disconnect in the mining and metals sector, which is the gap between the potential from digital transformation and the poor track record of successful implementations. The digital disconnect exists, not because of a lack of engagement from the sector, but because of a range of practical issues that continue to challenge the industry.

This paper, largely written from the operator’s perspective, expands on the potential benefits of digital to help exploit the number one operational opportunity in mining – productivity. It also explores the common pitfalls, which include lack of practical pathways to an aligned vision, unclear accountabilities and poorly defined digital business models. Understanding these pitfalls will help answer the question:

“With so much opportunity, why is the road to digital transformation littered with stalled or failed endeavors?”

Addressing the digital disconnect will be critical to succeed in the rapidly changing digital world.

Definitions and scope

Terms such as digitalization, digital transformation and analytics, when used without clear definition, can lead to confusion within an organization, and, in turn, can result in misguided and poorly scoped projects. For the purposes of this paper, “digital” (and variants thereof) or the process of moving to “digital mining” is “the use of electronic tools, systems, devices and resources that generate, store or process data to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.”

Digital mining: The evolution

Digital mining is not new; it has been with us for over half a century. Over the last few decades, the mining sector has embraced the introduction of new technologies, such as mainframe and personal computing, processing plant control systems, Despatch, Global Positioning Systems (GPS), mobile broadband, cheap sensors and data storage, through to cloud computing. Significant benefits have already been realized from digital mining, including:

Crowdsourcing
The introduction of global brainstorming to mining enabled cost reduction while speeding up the data sifting process to identify possible greenfield deposits.2

Simulation modeling
This has underpinned the decision-making for Australia’s multi-billion dollar iron ore and coal expansions since the early 2000s.

Mine planning and optimization tools
Applying intelligent optimization technology, devised by the COSMO – Stochastic Mine Planning Laboratory of McGill University, has improved production forecasts from 5%-25%.3

Mine monitoring and control systems
Better results have been achieved through remote operations centers that allow companies to monitor activities happening hundreds of miles away via satellite link.4 BHP Billiton is testing the use of sensors that could increase the grade of copper being sent to its processing plants by up to 10% and offset the need for costly plant expansions.5 Goldcorp has deployed CISCO’s “Connected Mine” solution at its Éléonore mine to track people and equipment at all times to improve the efficiency of its operations.6

Waves of digital transformation since 1950

Source: EY and Graham Walker, Consultant, Productivity and Value Chain
In the digital world, the desired end state for mining and metals companies has been generally accepted. This future is characterized as one where decision-makers (either human or automated) rapidly optimize decisions to maximize some objectives (e.g., cash flow, NPV) through the efficient use of resources (e.g., ore body, assets, labor), subject to some constraints (e.g., market, regulatory, ethical). This decision-making process strives to make the most effective decisions through the most efficient use of the available resources. Various aspects of this vision are already playing out in differing degrees of aspiration and scale. These developments are maturing in parallel with an increase in commentary highlighting the opportunities offered by analytics, big data, Internet of Things and machine learning – terms that are used liberally and often with little definition.

Against this backdrop, the mining and metals companies are looking for a sober assessment of genuine potential from digital transformation along with the implementation pathways, which take advantage of the opportunities while avoiding common pitfalls.

2 “Companies use crowdsourcing to innovate through downturn,” The Mining Hub, 24 November 2015.
5 Ibid.
Productivity remains the number one operational risk in the mining sector particularly in the bulk commodities. Despite recent improvements in cost reduction and labor productivity, asset productivity continues to lag, and this is the next area miners need to focus on. To address the productivity gap, miners need to focus on improving the management of variability in their organization.

The manufacturing industry is the best example of a sector recognized as a leader in asset productivity as measured by overall equipment efficiency (OEE). By adopting a manufacturing mindset, miners can better manage variability and hence improve productivity.
We believe there are three key elements to this:

- Digital alignment to the productivity agenda (digital as the enabler)
- A market-to-mine approach to the business (end-to-end)
- Leadership and culture to support elimination of loss (zero-loss focus culture)

Digital can enable new ways to drive productivity, manage the variability challenges of the sector and pursue commercial excellence. For instance, Barrick Gold teamed up with Cisco for a “digital reinvention” of its mining business in order to improve productivity and reduce costs. The initiative will help the gold miner meet its target of reducing its all-in sustaining costs to below US$700/oz of gold by 2019.7

Some examples of what mining and metals companies can achieve with the right focus on digital include:

- Optimizing plans and productivity rates across any operation and managing variability under any conditions: Digital will enable this through combining detailed ore body data with equipment operational and maintenance data, in a real-time environment, to produce alternative operating plans and the ability to refine these plans for variability.

- Enhancing asset availability and reliability: A move to digitally enabled predictive maintenance would allow for the extension of maintenance windows, reduced component and labor costs, and the minimization of costly breakdown events. Further, once the effective maintenance practices are standardized, the introduction of robotic process automation (RPA) and schedule optimization tools is possible.

- Understanding true end-to-end capability and systems bottlenecks, and supporting loss elimination: This is fundamental to the manufacturing mindset.

- Increasing agility and responsiveness to changes in market factors, such as demand, freight rates and customers’ buying behavior trends: This would optimize shipping and scheduling to reduce demurrage, maximize rail and port utilization, and also enable miners to capture spot markets and price premiums via sales contracted at different points of the value chain (e.g., on the water sales).

Digital will enable new ways to drive productivity and manage the challenges of variability in the mining sector.

7 “Barrick Gold partners with Cisco in bid to boost productivity,” Reuters, 12 September 2016.
The digital disconnect: Mining industry is yet to catch pace in digital intensity

Notwithstanding the long journey that digital mining has already taken in many parts of the world, the rate of recent development seems incongruous with the perceived opportunity.

Technology suppliers are rushing to grab their share from traditional mine services. Although mining equipment makers have invested substantial capital in technology, they might need to escalate capabilities to go beyond heavy equipment. For instance, Microsoft’s HoloLens virtual reality solution enables users to view, control and interact with 3D content using their hands and voice. This could transform the way mining professionals communicate and collaborate, for example, evaluating virtual mine designs or stopes without physically being there. Goldcorp has been working to implement possible applications of virtual and augmented reality (VAR) technology at its mine sites.8

So the big question is – if the benefits truly are so large and game-changing, why are the many established technological implementations not delivering on their full potential? Some of the common pitfalls driving this disconnect are:

Lack of detail on the implementation pathway
Even where there is consensus between stakeholders on the digital vision, there is little discussion on how to practically and effectively move from current state to this vision.

Perception of high costs
There is a valid perception from decision-makers that projects linked with IT systems often over-promise and under-deliver, often with a significant budget overrun. This perception delays decisions to commence a digital initiative.

Unclear accountability and disconnect with the current operating model
Owners of digital transformation are often unclear, and silo organizational structures are mismatched with a fundamentally different way of operating.

Ill-defined business model and business case
There is a degree of skepticism from leadership as to the robustness of the business case for digital and a lack of clarity on what the new business model will look like.

Lack of digital education and understanding
This can result in behaviors such as:
- An aversion to change or the implementation of something not fully understood
- A naïve rush to implement something on promise often through a misguided desire to appear progressive
- Remote decision-making creates dissonance with local leadership:
- Cultural difficulties of new remote operating models are not fully recognized.
- Operating site leadership is reluctant to concede critical process ownership to external teams, and the external teams often fail to deliver positive outcomes due to a lack of deep understanding of the site issues.
- Resourcing requirements to support a global business from a single location are underestimated, as are the difficulties in gaining access to accurate data.

Data systems lack maturity to support the future vision
Perhaps one of the biggest disconnects with the vision of the digital future is the quality of the data available for decision-making. While in some areas there are massive amounts of new data, there are other parts of the value chain with gaps in data quality and issues in gaining access to required information.

Systems and processes are already in place but are not being optimized
Business cases often do not recognize that there may be a significant digital footprint already in place. Leaders must understand why this footprint is not fully utilized before implementing new initiatives.

Having a clear understanding of the key elements of past successes and failures is critical to developing a truly transformational digital approach to the productivity challenge.
Digital mine of the future: What will it look like?

Amid continuous innovation and breakthrough in technologies, the industry can only estimate what it will look like 50 years from now. However, one thing is certain: Regardless of the mining method, the mine of the future will be digital, with composite technologies spread across the value chain.
**Rio Tinto – Mine of the Future case study**

Rio Tinto started its Mine of the Future program in 2008 to deliver improvement in productivity, cost performance and product quality.¹

**Aim**
- Reduce production costs and improve resource productivity by lowering variability and improving schedule efficiency
- Improve safety and minimize environmental impacts of operations
- Mitigate labor scarcity, especially in remote locations
- Improve working conditions to recruit and retain staff in the highly competitive labor market

**Implementation**

**Autonomous driverless trucks**
It used a fleet of unmanned trucks equipped with remote sensors at its mines Yandicoogina and Nammuldi in Pilbara, Western Australia. Artificial intelligence is used to learn the layout of the mine, avoid vehicle collision and transport loads with the least wear and tear, delay and use of fuel. Currently, 20% of the Pilbara’s haul truck fleet is autonomous.

**Smart drilling and blasting**
A fully autonomous drilling system at West Angelas is increasing the speed of open pit development while simultaneously reducing costs. The blast hole drill is guided by a satellite GPS to drill in the pit floor on a precise grid. It amounts to efficiency benefits as an operator is operating four drills.

Remote operating center (ROC) in Perth
It accommodates staff and electronic equipment to operate a range of assets and processes in Pilbara. It is embedded with visualization and collaboration tools, which provide real-time information across Rio Tinto's demand chain, to help optimize mining, maintenance and logistic activities across Pilbara.

AutoHaul
It will be the world’s first fully autonomous heavy haul, long distance railway system. It will reduce train cycle times by cutting the time taken for two shift changes, thus gaining an extra two hours per day use. It will also lead to less wear and tear and absolute compliance with the stated rules.

Results
- AHS trucks were operated for an extra 1,000 hours at 15% lower unit cost than conventional haul trucks in 2016.
- The autonomous drilling system has led to cost reduction and efficiency benefits with an operator running four drills.
- ROC has demonstrated higher efficiency, improved reliability, decreased variability and better identification of performance issues.
- Although yet to be fully implemented, the AutoHaul system is already reducing average train cycle times through optimized driving strategies. It has improved effectiveness with automated response to speed limits and alarms and public safety using automated detection systems.

Future course of action
Rio Tinto is now looking to integrate the entire suite of machines and processes to build a fully interconnected system across the entire value chain. Integration on an open platform will allow the miner to reach end-to-end optimization. For instance, the company’s “mine automation system” (MAS) pulls in data from many sources, which is then visualized through RTVis™ – Rio Tinto Visualisation. This provides real-time easily usable information and maximizes equipment utilization.
Unique challenges faced by the Indian mining industry

India’s domestic minerals sector has been a significant participant in the global mining industry. While for several minerals India has among the largest resource base and production, for some others it is emerging as a demand driver of the global mining industry. As a result of increasing integration with global trade, the price discovery in the industry is more aligned with industry-wide trends, thus subjecting the sector to global risks, opportunities and competitive pressures. Thus, most of the drivers of digital adoption also apply to the Indian mining sector, for example, mine productivity, cost optimization, safety and social license to operate. However, the Indian mining sector is also exposed to several additional challenges and opportunities as follows:

Growth momentum
The Indian minerals sector lacks a strong growth momentum in key categories. Over the past few years, mineral production has been impacted by mine closures on account of judicial/regulatory affairs and lack of new mine allotments. Despite a vast natural reserve base, the sector accounted for only ~2.6% of the GDP in FY16.9 India has witnessed a fall in output of iron ore from its peak and continues to import some high-value items such as gold and copper concentrate. The coal sector, however, has achieved accelerated production growth.

Exploration
The mining industry has a massive unexplored potential largely due to low exploration budgets and limited participation of the private sector in the past. The presence of global mining majors or exploration community is low or declining. Exploration methods are quite traditional with limited contribution of geochemistry, geophysics, remote sensing, advanced technology and entrepreneurship of junior explorers. As the surficial finds deplete, or grades slippages continue, it will become increasingly complex to discover and evaluate deep-seated ore bodies.

Productivity
Productivity remains a major concern with miners. For example, domestic coal productivity trails far behind the average for the industry globally. In addition, given that open cast mines are ageing and ore grade is declining, miners will need to augment output from underground mines, efficiently, which will require technological advancements specific to geological conditions.

Infrastructure
Infrastructure is a great value creator for the mining industry. The Indian mining industry has generally struggled with constrained infrastructure availability, particularly roads/railways and port connectivity, which is a major impediment to access and development of mining areas, and mine-to-market logistics. Infrastructure, where available, is relatively expensive when benchmarked to competing producer countries for a similar service. Also, the need for ICT infrastructure is growing for accessing and operating in remote locations efficiently.

Regulations and Governance
India’s regulations and complex procedural requirements for the mining sector are not the greatest examples of certainty, clarity and efficiency when benchmarked with global peers. Time-consuming multi-level processes and feeble enforcement hinder the ability of the modern

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miner to focus on sustainable growth. Several projects have been abandoned due to delays in acquiring land and obtaining environmental and forest clearances. Even with the auction process starting to impart transparency in grant of mining concessions, subsequent procedures are too complex and time intensive until commencement of output. Relatively higher taxation levels have burdened the industry with a structure that is not globally competitive. As a result, despite the 100% FDI route, the mining sector has witnessed restricted FDI inflows and engagement by global mining players. On the other hand, fraud and corruption challenges continue to plague the industry, though only few players may be involved.

Price and currency volatility
Like most commodity businesses with a significant global trade flow, Indian miners have to follow global price trends, which have been extremely volatile. This necessitates them to constantly follow global events that impact demand and supply, align their product sale prices and account for currency variations. Such volatility creates immense stress on the cash flows and profitability of the players. This is particularly relevant as prices of most minerals are referenced in US dollar terms while most costs are in Indian rupee.

Environment, health and safety
Sustainable mining with responsibility for health, safety of all stakeholders and environment is an imperative for mining globally. However, the performance of Indian mining on such parameters has been particularly inconsistent, mainly because of inadequate sensitivity and sensibility toward this responsibility. However at times, factors that lend to this situation include complex and outdated standards and small-scale operations of the vast majority of the mining tenements. High occupational risks pose significant challenges to mineworkers’ safety and health standards. Against the backdrop of various mishaps, companies need to target zero-fatalities and minimize health hazards arising from on-site pollution. Also, the environmental performance of a mine and its impact on communities need to be strictly monitored.

Scale of operations
The relatively smaller scale of mining tenements and operations in India restricts miners’ ability to bring in desired levels of investment and deploy new technology, in turn lowering the efficiency in operations and productivity and also posing challenges in terms of productivity, safety, sustainability and governance.

The Government, industry and stakeholders are cognizant of these challenges that are somewhat unique or elevated in the Indian mining sector. Reforms and other measures to alleviate them or manage their impact are underway. While such long-range steps progress at varied speeds and intensity, the industry needs to move ahead with initiatives that it can simultaneously undertake to combat these challenges. An efficient way of addressing these challenges is employing smart digital solutions.

Unrealised sector potential
The majority of India’s vast reserves of key metallic and non-metallic minerals remain unexplored, signifying high potential for growth. Constrained by minimal exploration budgets, only 13% of the 575,000 sq. km. area with obvious geological potential has been explored. Even where the resource base is known, the actual mineral output for most minerals has been quite low – for example, annual output for bauxite and iron ore is only 0.7% and 0.6% of their respective resources in the country. India continues to be a major importer of thermal coal despite abundant resources. With India’s working-age population set to increase by 220 million over the next 20 years, urbanization and rising incomes will accelerate growth in construction and manufacturing industries. In line with that, the thrust on infrastructure investment through the Housing for All by 2022 campaign, modernization of railways and reforms in the power and real estate sectors will lift the demand for minerals and metals. In addition, the Make in India campaign, which targets to achieve 25% growth in the manufacturing sector by 2020 from 17.1% currently, will further push the domestic consumption of minerals. It is thus important that Indian stakeholders scout innovative ways of expanding output, rather than increasing their dependency on imports.

10 “India to Deploy Flying Camera Drones to Track Illegal Miners,” Bloomberg, 02 February 2017.
The Government, public sector and private sector players in the Indian mining sector continue to aim for growth, operational efficiency and sustainable mining through technology deployment, driven by the Digital India, Skill India and other campaigns. While technology adoption is gaining pace, it still lags behind, for example, with only 1% of the data generated being analyzed.

As the industry progresses toward complete integration across the supply chain, it has undertaken several “smart initiatives.” We outline below the currently known developments that are relevant to address the above challenges and also the key themes that hold promise of immense potential.

**Enterprise integration and organizational efficiency**

Large mining companies are focusing on adopting technology to achieve enterprise integration and organizational efficiency. While large private mining companies have been early adopters, public sector companies are increasingly adopting technology to achieve these objectives.

- **Coal India Limited (CIL)** has achieved savings of INR8 billion through e-tendering and reverse auction on an e-procurement platform. The company is leveraging ICT for other business operations such as finance, material management, personnel, production, and sales and marketing. CIL is also implementing GPS / GPRS-based vehicle tracking system, electronic surveillance and RFID tagged trucks to restrict unauthorized activity and enhance productivity.

- **Hindustan Copper** has implemented an enterprise resource planning (ERP) solution across segments such as manufacturing, maintenance, marketing, finance and materials. The centralized business platform has enabled faster decision making and real-time visibility as well as standardized processes and management systems, thereby strengthening the financial management, supply chain management, customer service and HR functions.

- **MECL** is progressing with a full-scale ERP implementation to centralize the data and management system on a single platform.

**Productivity and growth**

Aside from incorporating integrated enterprise platforms, miners are also taking steps to embrace innovation to enhance productivity and enable growth. There is increasing recognition of long-term cost and productivity benefits.

- **Hindustan Zinc** has placed orders for Atlas Copco’s advanced, semi-autonomous equipment for five of its mines in north-west India. This is in line with its efforts to improve productivity and safety while significantly enhancing the underground mining output.

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15 ibid.
Northern Coalfields, a CIL subsidiary, plans to use unmanned aerial vehicles (UAVs) for survey and ground profiling of 4 of its 10 mines. The miner has introduced operator independent truck dispatch system (OITDS) in five mega projects and laser scanner for surveying and monitoring mines. Further, it is looking to increase operational efficiency by introducing a digital drive in draglines and shovels, and providing real-time interface facility for monitoring equipment and payload data as well as vehicle health.\footnote{17 “Coal India arm Northern Coalfields banks on drone technology play in mining expansion,” Financial Express, 04 July 2017.}

Vedanta has engaged Siemens for a digital fleet Center solution, which will link its power plant assets in Punjab and Chhattisgarh to a monitoring station. This will reduce unplanned outages, optimize costs and improve efficiency. In addition, for its power plants, the company is considering digital technology for predictive maintenance and to better management of fuel needs.\footnote{18 “Siemens digital solutions to connect Vedanta power plants in India,” The Economic Times, 18 May 2017, via FACTIVA.}

MSTC Limited has launched “M3 Metal Mandi,” a portal for metal transactions that aims to benefit micro small and medium enterprises (MSMEs) by bringing in transparency and a user-friendly interface for transactions.\footnote{19 “MSTC launches ‘M3 Metal Mandi’, a virtual market for metal transactions,” The Economic Times, 25 October 2016.}

While digitalization is catching pace with big miners, it is not as yet a priority for the medium and small operators, who continue to deploy older technology and stick to conventional mining methods. Visibility of cost-benefit for smaller mines and uncertainty of benefit realization are the main inhibiting factors.

**Exploration**

Initiatives to digitalize various stages of exploration are underway.

For example, Geological Survey of India (GSI) launched an Online Core Business Integrated System, an open IT platform, to share quality geo-scientific data through digital channels for socio-economic and scientific gain. The comprehensive data management system will deliver all baseline and exploration pre-competitive data to its stakeholders, including Ministry of Mines, national and state level earth science organizations / departments, industry and citizens. It will provide the following services:

- Enterprises Portal, which will have all of the 6,000+ GSI reports containing geological information such as maps and reports.
- Access to spatial data portal containing Open Geospatial Consortium (OGC) compliant map service across thematic domains
- Ground, airborne and marine geophysical data collected by GSI
- Virtual repositories of resources such as 2D and 3D images of rocks, fossils, meteorites and natural geological sites

The Government’s goal to fast-track big picture projects will pave the way for breakout of virtual technologies, which will increase productivity and the success ratio. For instance, use of VAR, combined with artificial intelligence and machine learning as well as data analytics to map underground resources in a 3D form, will help companies pinpoint drilling targets with more accuracy than traditional methods. Resource data is fed into a virtual reality model to create increasingly accurate new models of the underground deposits.

**Governance**

Authorities are increasingly adopting the “digital way” to improve transparency in the management, mining and transport of commodities, governance and control:

- The Ministry of Mines launched the Mining Surveillance System (MSS), a satellite-based
surveillance network to check illegal mining via remote sensing activity. It uses satellite images generated using space technology and overlaid on geo-referenced mining maps, which will go a long way in encouraging systematic mining.

- The Ministry has partnered with Bhaskaracharya Institute to curb illegal mining across major minerals, by superimposing all the maps of mining leases on digitized cadastral maps. Out of the total 4,000 mines of major minerals, digitization work of around 3,000 mines is reported to have been completed.

There exists a need to digitally consolidate and connect smaller mines and operators. The Government is planning to deploy drones, to not only limit its revenue losses and prosecute the mineral rights’ violators but also curb environmental damage.20 The use of UAVs will also boost miners’ confidence in their ability to control unlicensed activity.

**Regulatory and procedural streamlining**

In the past, policy reforms were seen as the go-to-solution for challenges relating to regulatory and procedural uncertainties. However, as technology evolves, its application can “quick-fix” some long-pending issues.

- In one of the initial moves to digitalizing its systems, the Government launched a web-based portal to improve efficiency and bring transparency in obtaining environmental and forest clearances. It automates tracking of proposals, and displays their status at each stage.21

- Other technology options include the e-auction initiative and the pilot stage Mining Tenement System (MTS). The MTS involves automating the entire mineral concession lifecycle starting from identification of areas for mining / exploration and ending with closure of the mine, and connecting the various stakeholders for real-time transfer of electronic files and exchange of data. MTS will not only enable online filing of applications but also identify the areas for various types of mineral concessions. This would involve integration of web-based technology services with a geographical information system (GIS), so that information could be shown spatially in the form of maps.

**Infrastructure**

The initial waves of technology investments connected operations with corporate and reporting processes through enterprise resource platforms. These efforts to consolidate operations across the enterprise have driven a significant investment in digital infrastructure, to connect remote locations to telephone, internet and video networks. In addition, the manufacturing execution system (MES) is a standard network at a plant operations level. Drones and GPS-enabled vehicles are being considered to tap inaccessible yet potentially mineral rich areas. In addition, miners are increasingly employing smart sensors to get real-time insights into the performance of the infrastructure.

As and when the size and scale of operations expands with tier 1 deposits of global scale and competitiveness, the sector may start to witness more investments in digital infrastructure. Examples include what Rio Tinto’s center in Western Australia and Adani’s plans for a remote operations center (ROC) for its Carmichael project, in Queensland.22 ROCs have great potential in poorly connected or insurgency prone areas, as they allow miners to extract ores and run operations with restricted access.

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20 “India to Deploy Flying Camera Drones to Track Illegal Miners,” Bloomberg, 02 February 2017.
Given that even vehicle automation is in nascent stages, miners and authorities need to co-develop innovative solutions to alleviate the lack of infrastructure in some mineral regions in India.

**Human capital and skill development**

The thrust on expanding domestic output and the growing focus on Make in India have increased demand for a skilled and digitally literate manpower. However, the mining sector has not been the preferred choice for the new educated class entering the workforce. This can be a major roadblock to technological advancement in the sector.

To address this gap, the sector is increasingly adopting training programs to skill its future workforce. For instance, the Ministry of Micro, Small and Medium Enterprises signed an MoU to launch Bharat ERP – an initiative to digitally enable ~30,000 MSMEs. Similarly, Siemens has engaged with the Ministry of Industries and Mines, Government of Gujarat and Steel Authority of India in the past through MOUs and is training employees to work in digitized factories. FIMI is actively collaborating with the Ministry in skill development in the mining sector.

The skill challenge, however, cannot be addressed overnight, as there is a long gestation period in skill acquisition and absorption. Recognizing the need, Vedanta recently launched a pilot project to promote digital education in schools, in collaboration with the Karnataka Directorate of Education. Skill training also requires significant investment as most mines in rural areas have little or no infrastructure for training centers. While the Ministry of Mines has prepared a skill plan and the Government is ramping up its Skill India mission, the industry needs a stronger public-private participation to widen the scale of technical education, trainings and mentorship programs.

**Mine safety**

None of the benefits of digital application are more important than mine safety. However, the investment therein has not been as expected. Mining fatalities have not been eliminated. However, some miners have initiated efforts, for instance:

- Tata Steel’s Noamundi iron mine is the first mine in India to launch “Drone Application in Mine Monitoring” (DAMM). Its objective is to inspect safety zones and lease boundaries, and monitor mining and reclaimed areas as well as quarry and dump profiling.

- Hindustan Zinc is also looking at a host of smart solutions for its priorities of zero harm to people, host communities and environment. It is establishing an underground Wi-Fi network across its mines to facilitate asset tracking, real-time visibility of operations, tele remote operations and VoIP-based communication.

The industry needs to increase the adoption of safety technologies such as mobile proximity warning systems, wireless methane sensors and inertial navigation to locate trapped workers as well as curated solutions such as Wipro’s Predictive Risk Intelligence Management and Caterpillar’s intelligent mine management. Miners can also consider tools such as micro-seismics to locate rock fractures and predict impending roof falls, rock bursts or any other hazards in working area.

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24 “Siemens opens its first digital factory in India,” The Economic Times, 06 July 2017; “Siemens to drive skill up-gradation across industries in India,” Siemens India, 30 October 2013.  
Industry views on digital adoption in Indian mining

The following are excerpts from views of mining industry on adoption of digital:

- Digital is not an alien topic for the mining fraternity and we are building employee awareness on the issue.
- There exists a wider scope for integration of mining operations, including exploration, ore extraction and processing, in comparison to business and technical support processes, which have already advanced.
- There are varied opinions on the hindrances in moving to “digital mine”. While some find technological capability and cost as prime issues, other believe business case clarity and cyber risk are limiting digitalization.
- Sensor technology, integrated data platforms, big data and advanced analytics have significant potential for application.
- Asset management and maintenance, productivity, supply chain integration and safety are the future of technology adoption.

“Innovation and Sustainability are at the core of our strategy. As a part of that thrust, we use digital technology extensively in mining but also in increasing reliability and output of our plants and equipment. We intend to intensify the use of digital further, not only to optimize but also for breakthroughs.”

- CEO, Diversified mining major
As the Indian mining industry moves into the digital age, technology-enabled solutions will become a necessity for survival and growth. The following are likely to be the prevalent themes in the Indian mining sector over the near future:
The following are specific technology themes and domains relevant to mining, along with their currently known and future use cases. They hold promise of immense benefits for the mine operators.

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<th>Technology domain</th>
<th>Use cases and benefits</th>
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| Industrial Internet of Things                          | ▪ A system of interrelated computing devices, mechanical and digital machines and unique identifiers for employees to transfer data over a network without human intervention  
▪ Used for collection, processing and analysis of machine-generated data  
▪ Uses results to drive improvements in design and execution, leading to smarter and faster decision making  
▪ Pit-to-port optimization based on operational insights from analysis of diverse data signals (drilling parameters and geological models)                                                                                                                                                         |
| Automation (Automated vehicles / autonomous haulage System) and robotics | ▪ Productivity improvement by cutting down shift breaks and delays due to breakdowns etc.  
▪ Compensates for scarcity of mining staff  
▪ Improved safety and minimal collision probability  
▪ Higher energy efficiency by lowering fuel use  
▪ UAVs – High resolution ground scoping and profiling, real-time updates on production progress and stockpile sizes; minimizes risk by identification of potential hazards                                                                                                                                                         |
| Big data, advanced analytics and simulation modeling    | ▪ Identification of inefficiencies and optimization of bottlenecks in procurement and production, and increase in collaboration between departments  
▪ Better decision making backed by real-time big data analysis  
▪ Reduction in non-productive time delays  
▪ Identification of true cost drivers and finding correlation between factors  
▪ Simulation modeling – Optimization of design without physically drilling, thus lowering the investment, waste and physical footprint of the operation                                                                                                                                                                                                                                                                 |
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| Mobility (information sharing mobile platform) | • Uses geo-position devices to allow tracking of employees, assets and equipment  
• Positive impact on health, safety and environment and ability to limit workers from hazardous situations  
• Enables better communication, increased worker productivity and better recording of field data |
| Cloud computing | • Cloud technology – Assistance in centralizing functions and controls, as well as standardizing multi-location operations  
• Platforms support collaborations, measurements and analysis of the business processes that compete globally  
• Direct interaction with suppliers  
• A greener and sustainable choice |
| Condition-based monitoring (CBM) and predictive maintenance | • Telematics-enabled sensor data for monitoring equipment degradation and predicting failure based on history or patterns  
• Increase in the health / longevity of the mining equipment fleet  
• Detection of impending failures early enough to save the equipment / machine  
• Automatic scheduling of maintenance activity, skill or spare parts required |
| Centralized remote command center | • Live view of remote mines, and analysis and prediction of factors such as production output, equipment status and other conditions  
• Platform for bringing more accountability and collaboration in process management  
• Safer work environment and faster tracking and evacuation |
| Robotic Process Automation (RPA) | • For performing manual, rule-based administrative and repetitive tasks efficiently while reducing time and cost  
• Replacing manual steps in procurement, inventory management, invoicing and payment processing by digital processes, with access to real-time analytics to support adaptive decision making |
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| Artificial intelligence           | Machines enabled to derive input from various sources such as mining hardware, worker equipment and databases to support miners in problem solving processes  
Helping decision makers make more informed choices, optimize yields and minimize environmentally harmful inputs  
Intelligently increasing efficiency by removing bottlenecks and improving operational throughput on an ongoing basis |
| Wearable technology               | Personal protective equipment (PPE) enhances productivity, safety, and long-term sustainability by preventing accidents  
New industrial applications for heads-up displays, such as Google Glass can revolutionize the way industrial companies manage equipment and safety at a worksite  
Constant hands-free control of workplace’s resources, operations and machinery to enhance productivity |
| Ore optimization technologies     | ▶ Rapid mineralogical characterization improves grade control of the ore using a number of techniques such as mine face scanning, drill core logging and remote hyperspectral imaging  
▶ Cooperative Research Centre for Optimising Resource Extraction’s integrated methodology can reverse the trend of declining ore grades through solutions such as Grade Engineering and Integrated Extraction Simulator |
| Social media                      | ▶ Miners and geologists increasingly using data and analytics from social media to locate new mining opportunities — for instance, inputs and posts from hikers who end up gold panning  
▶ Early warning signals on risks, prevention and management of risks  
▶ For engaging community and government, communicating contribution, securing social license to operate and acquiring talent |
Critical success factors

- Alignment with enterprise goals and overall strategy
- Enterprise-wide integrated architecture
- Well-defined operating model and business case
- Clearly defined implementation pathway
- Leadership commitment
- Culture of innovation, co-development and entrepreneurship
- Clarity of roles, accountability and ownership
- Digital literacy and skill development
- Cyber security risk management
- Business process alignment with the future state
- Program management and quality assurance
If you would like to discuss any aspects of this report please contact

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