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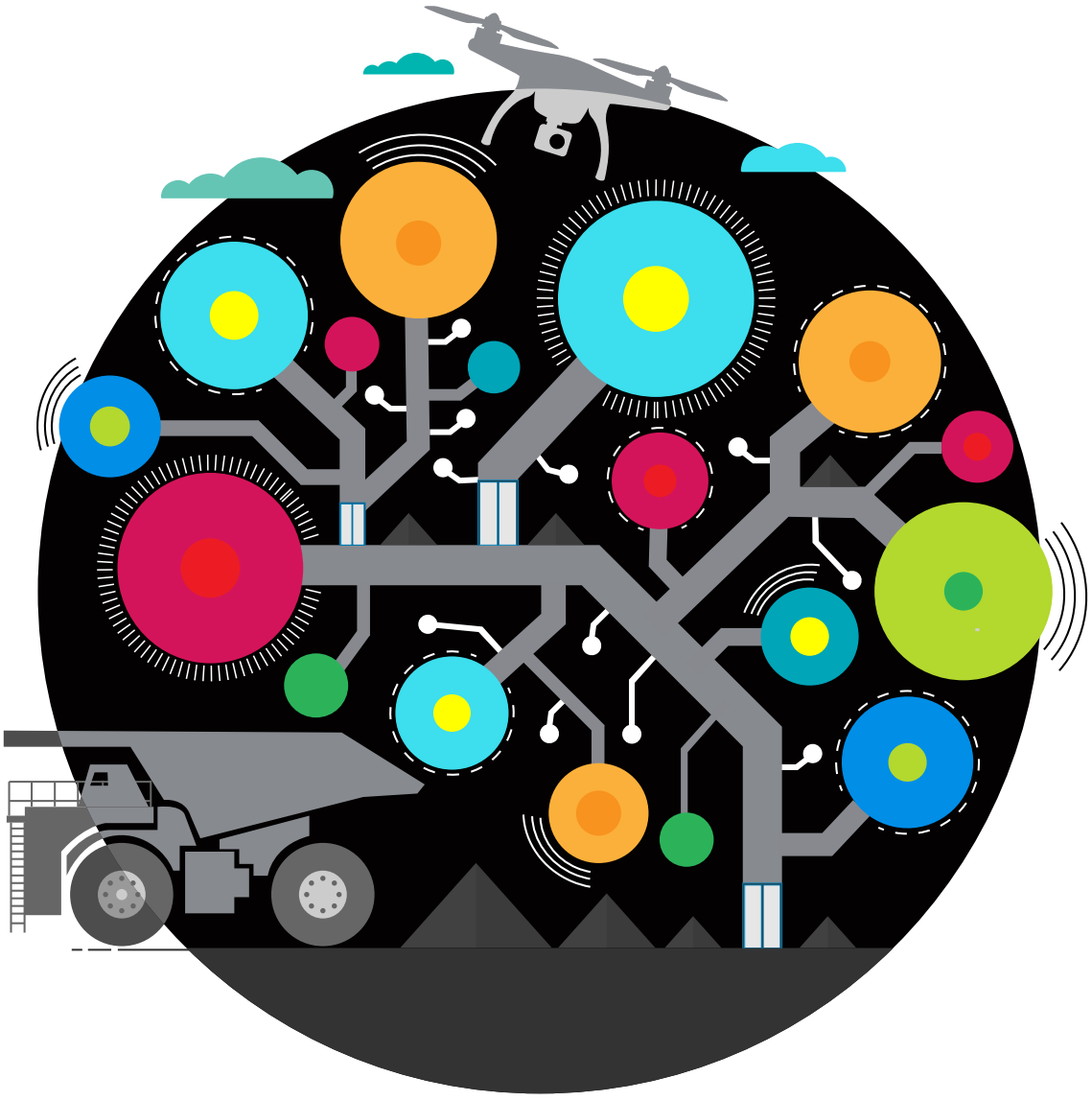


The Future of Mining in Africa

Navigating a Revolution

2018

"Of the many diverse and fascinating challenges we face today, the most intense and important is how to understand and shape the new technology revolution, which entails nothing less than a transformation of humankind...

My concern, however, is that decision-makers are too often caught in traditional, linear (and nondisruptive) thinking or too absorbed by immediate concerns to think strategically about the forces of disruption and innovation shaping our future."[1]

Klaus Schwab
World Economic Forum

[1] Klaus Schwab, "The Fourth Industrial Revolution", 2016

Contents

The Future of Mining in Africa

The rapid advance of mining digitalisation, coupled with regulatory changes, will change the way that African mines operate and require careful consideration of the impact of those changes to mining stakeholders.

The digital revolution

The velocity of change sweeping across industries is increasing at unprecendented rates. In this turbulence, many business leaders ask how they should plan for a world they cannot imagine in five to ten years time. Two key principles hold in such a world. Firstly, digital strategic choices do not rely on fortune telling, but rather entail becoming 'antifragile' – equipping an organisation to thrive under volatility. Second, engaging with the Fourth Industrial Revolution is not a passive observation, but requires the recognition that intentional choices will shape the economic and social landscape of the future. As Alan Kay quipped, "the best way to predict the future is to invent it."

Each industrial revolution – First: water and steam power, Second: electricity, Third: electronic automation, and now Fourth: convergence across physical, digital and biological domains – has fundamentally altered how human beings live and work. The Fourth Industrial Revolution (4IR) is finding expression in the form of computing power, digital devices, sensors, connectivity, analytics, cloud computing, cognitive automation, the internet of things, technological ecosystems, and user interfaces.

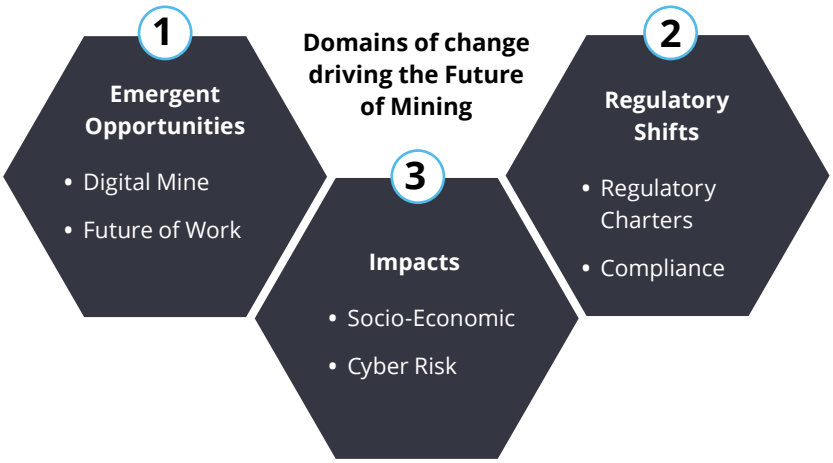
The digital age is set to disrupt the lives of individuals, communities, but particularly organisations. Mines are no exception to this rule, with far-reaching implications and important opportunities. Mines on the African continent need to be cognisant of both the impending changes to their business, and of the impact of those changes to the societies in which they operate.

Domains of change

Over the past five years, African mines have navigated a commodity price downturn, challenging labour conditions, regulatory changes, upward cost pressures and unpredictable international politics. The 4IR has emerged in the midst of this, presenting new opportunities and challenges for mining companies. Furthermore, regulatory changes and societal impacts require mines to become not merely compliant, but to adopt smarter ways of deriving value from regulation, while ensuring mutual benefit to surrounding communities and environments in which they operate. New skills, a changing workforce, organisational restructuring and adoption of new technologies are all important to navigate in this era.

Deloitte sees three interacting domains of change that will shape the future of mining:

The first domain is that of **emergent opportunities** from 4IR for mining companies, including what a digital mine will look like and the future of working at a digitally-enabled mine. Covering incremental improvements to existing challenges through digital infrastructure and improved planning and decision-making, these changes will drive competitive innovation and sustainable mining practices.



[2] Nassim Nicholas Taleb, "Antifragile",

The second domain are the **regulatory shifts** in African mining, and the actions that this regulation incentivises. In South Africa this includes the recent mining charter, whereas the rest of Africa is working through issues from nationalisation through taxation amendments. Managing the complexity requires creating value beyond compliance.

The third domain is centred on **impacts** that transitioning to a digital mine will have on the socio-economic wellbeing of broader mining communities as well as the cyber risks that this transition entails. The impact of digital disruption should be managed through adopting a shared value framework, leveraging new possibilities that Digital brings to develop new mining skills, community education and supplier development. Cyber risks require awareness, collaborative strategies and executive-level oversight to ensure these are mitigated.

The three domains (emergent opportunity, regulation and impact), inform the five sections that comprise the Future of Mining.

Section 1: Digital Mine
Mines have an assortment of emergent opportunities when designing their digital mine, from integrated efficiencies through digitally-enabled technologies to complete overhauls of business models.

Digitised geological information, outsourced identification of mineral deposits, autonomous mining equipment, real-time data capture and feedback, wearable devices for maintenance and operator safety, drones for inspection and monitoring, a mobile connected workforce, 'digital twins' to simulate mining assets, integrated remote operating centres - are just some of the digital changes we see.

Section 2: The Future of Work
A significant impact is anticipated from the 4IR on the constitution and collaboration of the workforce, as local expertise and manual processes give way to global connectivity and technological augmentation.

Dangerous, labour-intensive extraction processes will transition to safe, remote monitoring of equipment. Digitised processing will change the number of mining personnel required as well as the nature of their skillsets. Workforce mobility and flexibility will better align the timing of needed skills with the remuneration structure of those employees.

Section 3: Regulatory Environment
The increasing rate of change will present challenges as mines seek to embrace the requirements of operating within their regulatory environments. The interdependence of regulators and mine operators creates impetus for all stakeholders to work proactively towards common outcomes.

In South Africa, the Amended Mining Charter outlines the expectations of rights holders to invest in the social reformation of the industry, including new elements, ring-fencing of certain elements and a revised scorecard. The rest of Africa is introducing policy from nationalisation through taxation amendments, all of which require mines to consider value beyond compliance.

Section 4: Shared Value and Socio-Economic Impact
Adoption of digital technologies carry broader implications for the communities in which mines operate. Fears around job reductions as well as emerging opportunities to invest in affected communities together inform the socio-economic considerations for the digital mine.

As select job categories give way to automation, reskilling and appropriation of new skills will be critical for mining companies. Socio-economic value creation within mining communities carries a lower cost and greater impact in the emerging landscape, but is entirely dependent on the intentional use of digital technologies to empower the broader society in which mines operate.

Section 5: Cyber Risk
Companies transitioning to the digital future must carefully consider the cyber risks involved, to ensure that the benefits of the 4IR are not threatened by ecosystem vulnerability nor concern on the reliance on automation that can have an effect on employees lives. Collaborative partnerships and awareness of relevant risk management methods serve to mitigate such risks.

Strategic choices for miners

As always, the strategic choices made by a mining organisation will determine whether they stand to benefit from pioneering the new wave of possibilities, or are caught off-guard by the changes in the industry around them. This thought series is intended to equip mining companies with full sight of the choices available to them from the Fourth Industrial Revolution, across the spheres of implications, regulation and impact, enabling them to thrive in times of uncertainty.

The Digital Mine

"I think the industry has not really embraced what digitisation and technology can do. And I think that in the next piece we have to get our minds around and where you should expect to see a quantum change in how we do things." **Graham Kerr, South32**

The Mining Challenge of Today

Mining operators today across commodity types and across the world are facing the combined challenges of declining ore grades and operating efficiency. Responding to such challenges is particularly difficult in the mining environment given significant variability encountered in ore bodies and operations. This is compounded by costly and capital intensive infrastructure requirements, distant planning horizons and lengthy implementation timelines, not forgetting the inherent danger in the operating environments subsequent critical safety considerations.

Mines have thus felt constrained and uncertain as to how to improve. Lacking real visibility and access to accurate, complete, timely data or business options they struggle to make meaningful, transformative changes to their businesses. The result is a reactive response with inadequately informed decisions; with mines continuing to follow the approaches of old – sweating their remaining assets and working harder for smaller gains.

With the low hanging optimisation fruit gone, the innovation focus rests now on two stages: firstly step-change innovation to address current challenges; thereafter in the second stage the focus shifts to possibilities of the future mine. We first focus on addressing current challenges to achieve the required step-change in performance.

Stage 1 – Addressing Current Challenges Innovatively

- **Structural variability in the orebody:** Structural variability in the orebody will always exist, and while mining organisations cannot change this, they can create faster and more informed response mechanisms enabled by digital technologies.
- **Lack of visibility of what should be done:** Mining processes lack visibility to real time, accurate information. This hinders the ability to track resource performance and increase equipment uptime. More complete, timely, and insightful information and leading indicators enables leadership and frontline teams to intervene more proactively. Incorporating smart workflows that highlight process deviations will trigger the desired response mechanisms and support the required behavioural change.
- **Management induced variability:** Operational decision-making is generally siloed, which results in uncoordinated action that does not address root causes. Digital enables more integrated and informed response mechanisms to highlight best-suited holistic options and trigger immediate coordinated action.

Stage 2 – The Digital Future

The future is being shaped by the Fourth Industrial Revolution. Recent years have seen significant decreases in technology prices combined with advances in the capabilities of machines, robotics and automation, data capturing, storage and processing, artificial intelligence and critically our interaction as humans with these machines and data.

Many mines have considered themselves immune to the disruptions experienced in other sectors from advancements in digital technologies. However new capabilities, ever decreasing costs and improved access to technologies (digital democratisation) has bought the threat of outsider disruption right to mining's doorstep but also created an opportunity for miners should they embrace these technologies. Early movers like Dundee Precious Metals and Rio Tinto have already realised performance gains through digital transformation. Many others in the sector have started to follow suit as the digital revolution shift increasingly becomes an imperative for success and survival.

This digital future brings great promise. Digital advances will enable quicker and better decisions that reduce performance variability, and improve equipment utilisation and safety performance; while moving organisations from a reactive management approach to being able to look forward with insight and confidence.

What constitutes a future digital mine?

To understand what makes up a future digital mine, it is useful to refer to Deloitte's paper "The Digital Revolution – *Mining starts to reinvent the future"* which provides a detailed synopsis of the dimensions of a digital mine. Digital mines' transformation will be unique in focus areas and scale, but will generally include the following three areas of the value chain:

Core Mining Processes – automating physical operations and digitising assets

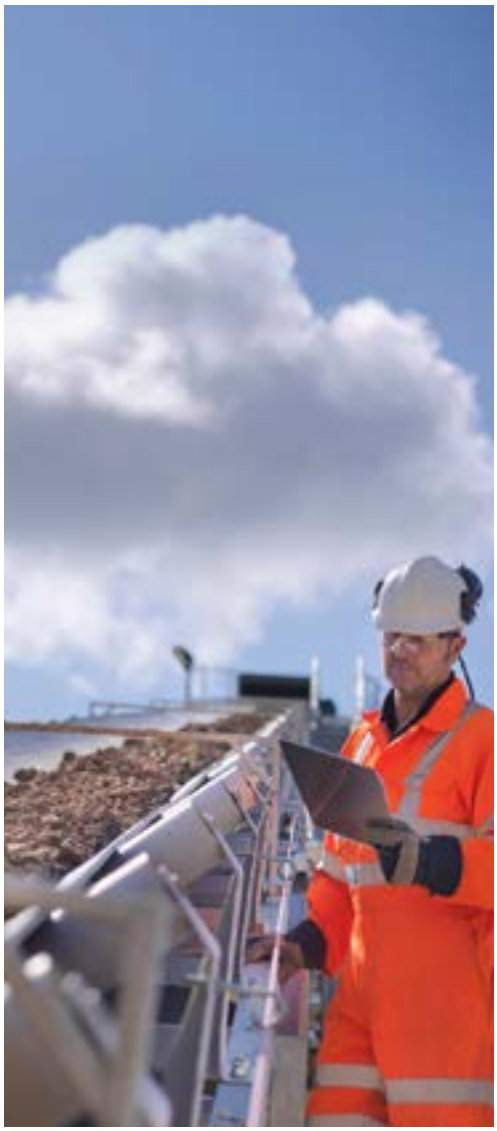
Autonomous vehicles will improve productivity, reduce costs and improve safety. Drones will be used for data collection, inspection, stock control and safety monitoring. 3D printing will reduce lead times and inventory holding costs for critical parts. Wearable technologies will be used for enhanced operator safety and support real time machine instructions. An internet of things (IoT) enabled sensor network will provide low cost real time data across operations. A "Digital Twin" will provide an accurate digital model of the physical environment including geological, engineering and asset information to simulate business and operational decisions virtually.

The Digital Mine Nerve Center Data – data-driven planning, control, and decision-making

The nerve center brings together real time data across the mining value chain in multiple time-horizons, to improve planning, control and decision-making, in order to optimise volume, cost and capital expenditure, and also improve safety. This further assists with visualisation and reporting, short interval control and operational improvement, future modelling, prediction and simulation.

Support Processes - Re-imagined ERP

The effects of digitisation will extend beyond the core operations to the supporting processes and systems of functions such as supply chain, HR, and finance. This will require a complete re-think of corporate structures and processes, and should consider opportunities to leverage Robotic Process Automation (RPA), the convergence between information technology (IT) and operational technology (OT), and integrated communication networks to support mobile workforces across all platforms.



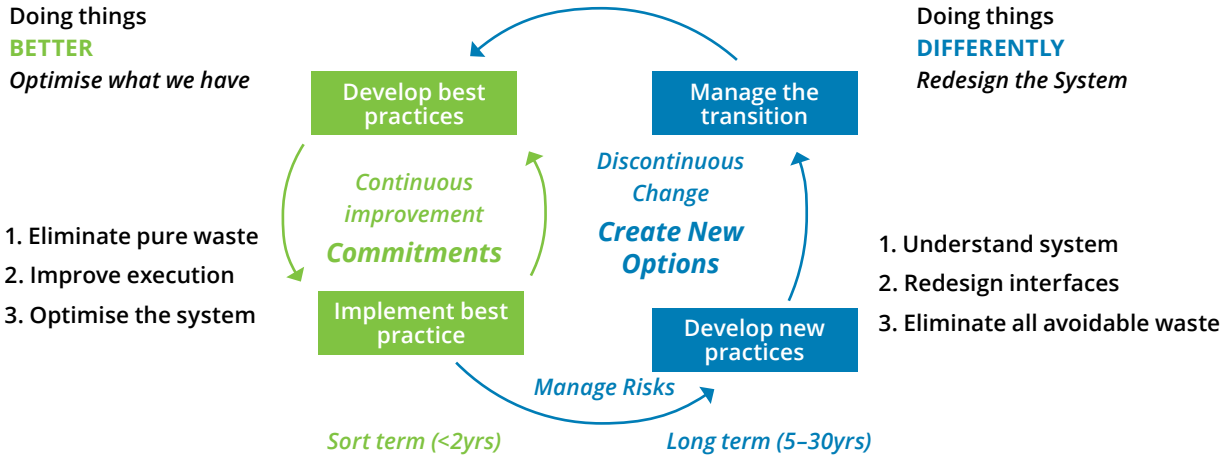
Opportunities in management decision-making and planning

Success will not come from adopting new technologies sporadically, rather the digital mine concept needs to be deeply incorporated into leadership's thinking and strategy with a view as to how to shape the complete business to create real business outcomes in a digital world. The game changer hinges on the ability to change how decisions are made, and ultimately on establishing new ways of work. Traditional governance models and stage-gate approaches to project implementation must be replaced with a more agile approach to execution.

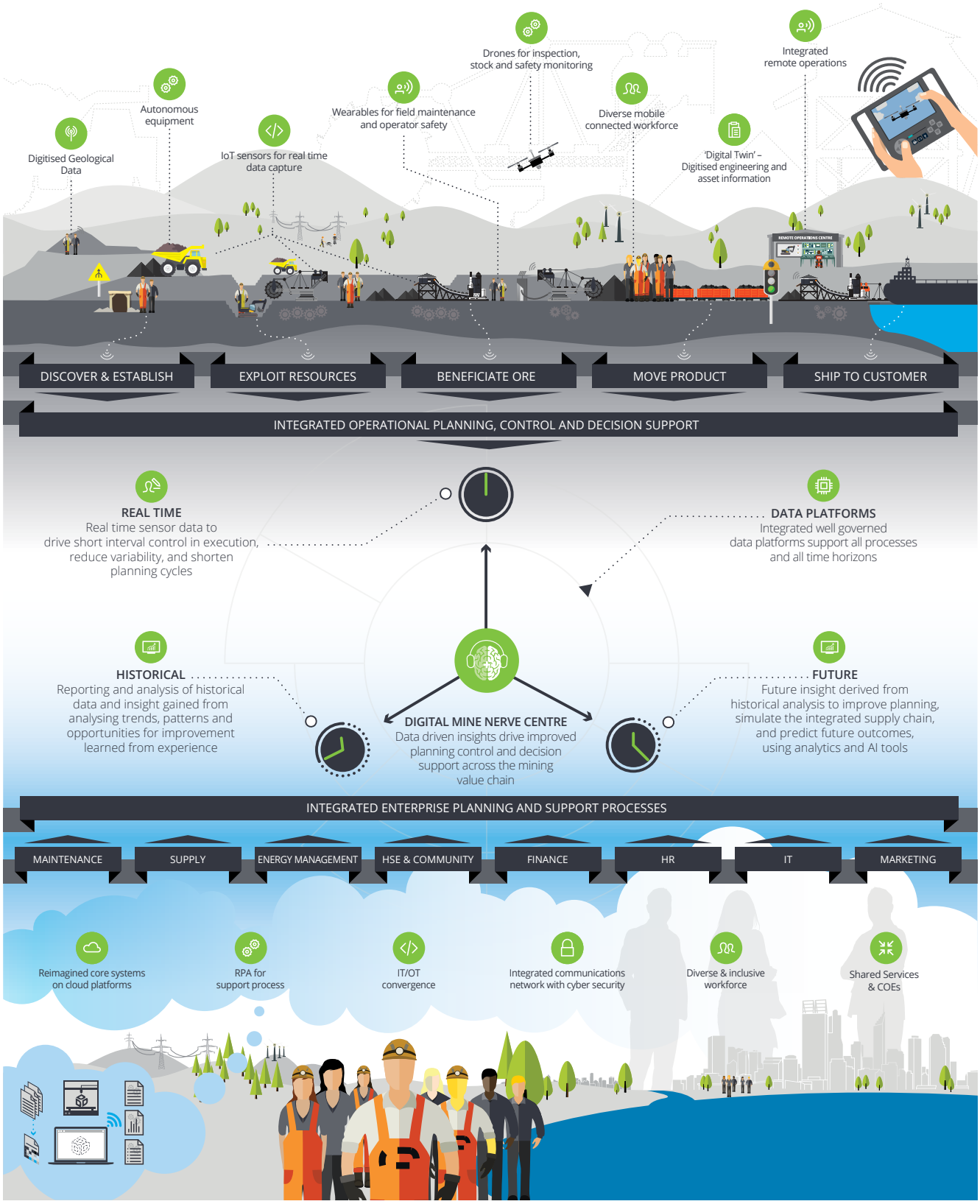
This will ensure that organisations can experiment with select digital use cases with minimal capital outlay, and accelerate value realisation while minimising risk. Ultimately the objective is not only to value preservation and creation for shareholders but also society and the environment within which they operate. The potential value realisation increases as organisations transition from doing things better to doing things differently:

- **Using digital technology to manage more effectively** – evidence based insights allows us to do the same work better (10-20% improvement potential)
- **Integrating information** – leveraging IT to automate process and make better system-wide decisions (20-30% improvement potential)
- **Redesigning integrated systems** Integration and optimisation of all technologies across a mine allows us to work differently (greater than 50% improvement potential in the impacted areas).

The cycle of continuous and periodic change



Starting from the bottom operational metrics at the mining face, organisations can build to up business views such as intensity of labour, energy and installed capacity. These support economic views for revenue, operating margin and asset efficiency. To demonstrate how digital interventions can create new value it is often useful to consider the impact on a use case basis, as illustrated below:



To enable the right kind of planning to support these new forms of decision-making, there are numerous technology advancements that will play a key role, including:

- **Integrated Real Time Resource Planning** – An opportunity across the value chain to improve the frequency of mine planning and scheduling through automated surveying and reconciliations of resources, combined with equipment, material and workforce tracking and visualisation would enable optimal matching of resources and equipment, demand planning and performance management.
- **Adaptive Mine Planning** – Mines already gather ore-body information from a number of sources, including drill hole data and face inspections. Combined with geological data the opportunity is to use sophisticated data analysis techniques to understand this better and do so quicker. This will enable rapid adaption of mining plans to increase yield efficiency and reduce non-productive mining time.
- **Predictive Maintenance** – Avoiding unplanned downtime. Utilising and applying predictive analytics on data already available from key equipment to predict failures and proactively schedule maintenance work orders, including integration into the supply chain for parts ordering. Moving from scheduled to more accurate usage or performance based maintenance will increase equipment availability.
- **Automated SHEQ processes and predictive safety** – Wearables enabled employee fatigue monitoring and communication, combined with position trackng, digital compliance logging and cognitive predictive analysis of safety incidents. This can help decrease utility consumption, improve operational efficiency and reduce safety incidents.
- **Maintenance Artisan Assist** – Automated breakdown logging, notification and repair process optimisation, supported by predictive trend and risk classification. Field workers functions can be enhanced by augmented reality enabled visual guides and smart remote support. Improving the quality and efficiency of maintenance work.
- **Short interval control** – Near real time tracking of execution against plan at a task level. This will enable leadership to manage operations on input metrics and leading performance indicators and provide the visibility to eliminate execution waste.

Transforming to succeed

The future digital mine has arrived and mining leaders need to navigate the path to transform. A successful transformation is dependent on:

- A comprehensive **organisational transformation** not only focused on technology, but on **people, culture and governance**
- **Integration of core and support processes** underpinned by a robust technology architecture
- A **transformed workforce** augmented by decision support and **real time performance management**
- **Resilient leadership** with a relentless **drive for value** realisation, coupled with **real endorsement** for **agile ways of work.**

The organisational transformation to a truly digital mine will focus on shifting away from siloed, traditional models to a business-driven, agile operating model underpinned by design thinking and data driven decision-making.

The Future of Work

Technology, work and people are changing. The future of work is fiercely debated in the light of emerging digital forces and the new world brings new opportunities for the workforce. Mines need to be able to quickly and accurately respond to the risks, strategic challenges, and work unknowns of the future.

Introduction

The continued rise in operating cost and complex ore bodies that have an impact on safety and the health and wellbeing of employees are putting pressure on mines to think differently about how they should operate. Mines are also working with a younger workforce that expect career progression and growth and continuous legislative changes forces mines to rethink how technology will enable them to be more efficient, effective and compliant.

Digital technologies are changing the way of work in the following three areas:

- **Work:** The type of work that people will do in the future
- **Workplace:** The structure and practices that enable people to create value in the future
- **Workforce:** The portfolio of workforces, people and machines, on balance sheet and contingent workers and crowds

What will the future look like in the mining industry?

The ways of working in the African mining sector will significantly change in the following areas:

Work will be digitised and technology driven

Mining operations have already introduced robotics and automation at certain mines. Digitisation will incorporate areas such as autonomous operations (trucks, drills), 'digital twins' in engineering and maintenance, and a multitude of different equipment sensors. Real time information, predictive analytics and monitoring of production, cost, efficiencies and employee data will be managed through applications.

Environment, Health and Safety

Real time information and predictive analytics enables proactive identification, mitigation and decision-making of environmental, occupational and operational risks.

Connected and agile workforce

Workers will be able to engage with their employers in a different way. The digital workplace enables digitally connected communication, collaboration and a more flexible, agile and choice driven workforce.

Diverse, agile and adaptable

The mine of the future requires leadership that embraces a culture of data-led decision-making and a new way of thinking and operating. Leadership and employees require different skills and capabilities that will enable them to be successful in this environment.

What is needed to get future-ready?

To support the successful implementation of technology, businesses need to optimise their operating structures and processes that will support the new way of work.

The following people management domains need to be addressed to become future ready:

Way of learning

The strategy and approach to learning will have to be a blend of technology enhancements and traditional learning. Examples of technology enhanced learning are audience response systems, virtual reality, augmented reality, mobile applications and computer based or eLearning applications. Traditional training includes classroom and practical instructor led learning. The success of learning relies on a learning management system that enables reporting, planning, tracking and monitoring of all learning.

Leadership

Leaders in a digital mining environment need to be able to adapt to a rapidly changing environment, different ways of working and different generations in the workplace. The changes to current and future mining would need a strong focus on leadership development, equipping leaders to lead and manage diverse projects and teams.

Performance management

Performance management at many organisations is not successful because of the strenuous paper-based processes and performance information that is not readily available. Digitisation should be linked to performance management systems to enable real-time information for better ongoing management of employee performance. Gamified performance management is an example of real-time performance information linked to incentive and reward programmes, as well as mitigation mechanisms for poor performance.

Workforce engagement

Engagement levels in the mining industry have become increasingly difficult due to large numbers of employees working across many sites. Employee engagement needs to improve by using digitised solutions which enables real-time information to be shared, data made available and two way communication channels to connect the workforce with management.

Organisational development

Due to socio-economic changes resulting from the digital revolution and legislative changes, mines are forced to revise the way they do business, run their operations and particularly, develop their people. To be prepared for the change, new technology and operating strategies will guide new forms of organisational development, including mechanisation, job automation interaction, process revision, skills re-alignment and development to adapt to new ways of working.

Regulatory and Policy Considerations

The complexity and volume of regulation and policy is continuously increasing and evolving. Changing needs and expectations of ecosystem stakeholders bring a need to deliver value beyond (mere) compliance. Technology and shared value can be a key enabler therein.

Introduction

The regulatory and policy environments surrounding mining operations are driven primarily by the intent to balance the economic value derived from mining activities (by various stakeholders, e.g. mine operations, local governments, communities) with the current and future social and environmental needs.

In recent times, there has been an increase in volume of regulation and policy, and more significantly a steady trend toward increased compliance requirements and targets, as a method to advance the social, economic and environmental imperatives. With expanding global footprints, the complexity and volume of regulation becomes less and less manageable.

This, alongside increased societal pressures, necessitates a rethink of existing methodologies and tools for monitoring compliance, as well as a need to redesign existing strategies to move away from compliance for compliance sake, and toward delivering value beyond compliance within an operating ecosystem.

The complexity of, and continuous change in the regulatory and policy environments in mining

The mining sector continues to experience scrutiny by regulators in Africa. The continuous introduction of new regulation and policy creates uncertainty, increased administration and costs for mine operations. In certain instances, this results in delayed investment in expansions of existing mines and the development of new mines.

Regulation and policy dealing with the issuing, maintenance and royalties linked to mining rights in Africa pose practical challenges to regulators and companies alike. With the fall in commodity prices and the negative impact on the industry's profitability and growth, regulation and policy has remained stable, with some noticeable exceptions. We anticipate that changes will begin to follow an upswing in commodity prices, driven by governments wanting to increase their participation in the mining sector in order to maximise their revenue generation during the boom period.

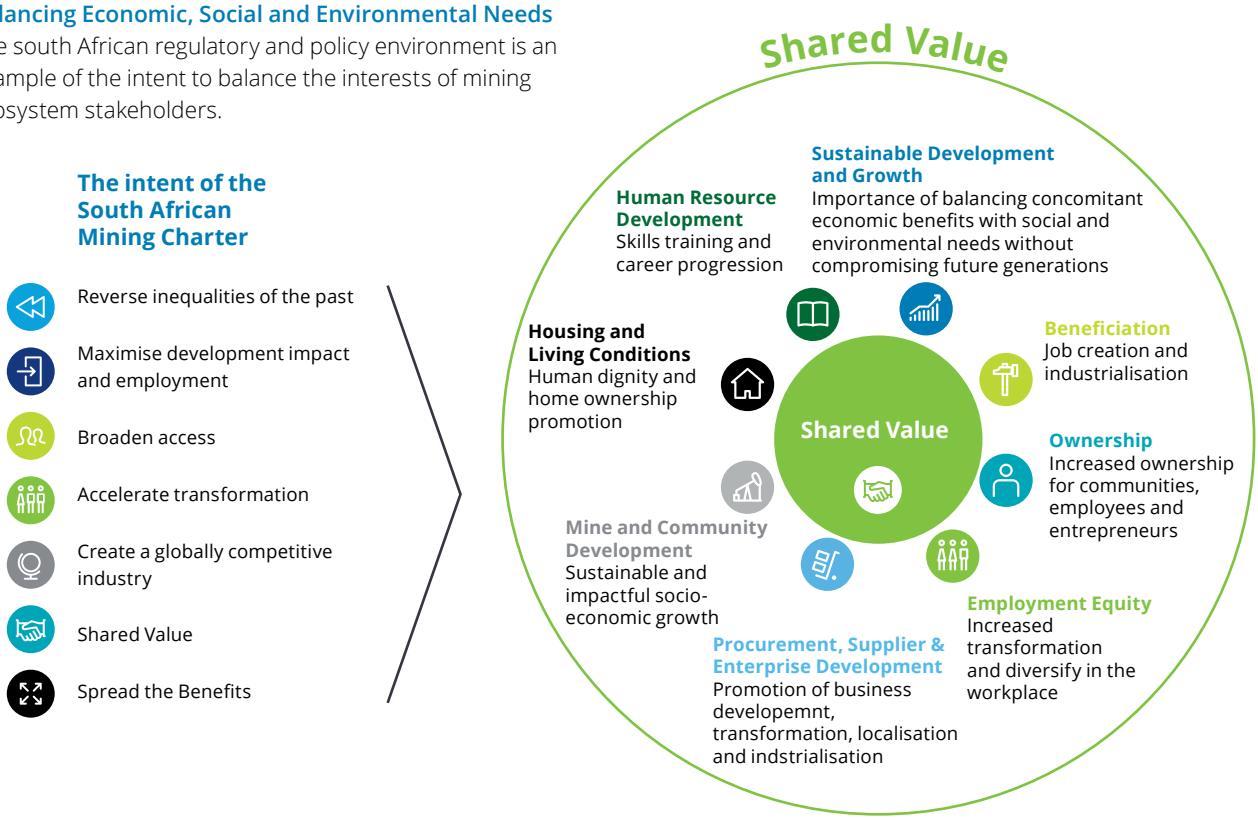
In some instances and jurisdictions, changes are introduced to attract new mining investments, while other jurisdictions operate in a state of complexity and uncertainty with limited appropriately drafted regulation and policy. It is common for investors to have to approach relevant ministers and agree on the rules. We have noted, however, that these practices are slowly being replaced with the publishing of complex regulations that are administered by various regulators.

South African Mining Charter

South Africa is currently witnessing the continued evolution of its regulatory and policy landscape through the anticipated second iteration of the Minerals and Petroleum Resources Act and third iteration of the Mining Charter. The Mining Charter is an example of continuously increasing compliance targets and requirements aligned to balancing of the above-mentioned current and future social and environmental needs.

Balancing Economic, Social and Environmental Needs

The south African regulatory and policy environment is an example of the intent to balance the interests of mining ecosystem stakeholders.



Some practical insights into the complexity of and continuous change in the regulatory and policy environments in mining in Africa include:

- **Zimbabwe:** Since 2009, there have been annual changes to the mining legislation in Zimbabwe. Of late, the mining regulatory framework is becoming relatively stable. Recent development in the mining industry are the proposed changes to the Indigenisation and Economic Empowerment Act to include platinum and diamond mining companies only, in which foreign persons cannot hold more than a 49% shareholding.
- **South Africa:** South Africa has recently concluded, through the Davis committee, the review of the whole mining tax system with a view to determine whether it is still relevant to meet the tax revenue budget. This review was influenced by the decision made by the ruling party in 2012 to introduce new tax legislation in order to increase tax revenue coming from the mining sector. The Davis committee published their final proposals in 2017 and they did not propose the introduction of any new taxes. Instead they proposed the overhaul of the current mining tax legislation to align it to other industries like manufacturing.
- **Zambia:** Zambia introduced a windfall tax which they repealed within a year of it being introduced. Alongside this, it introduced regulations which make it extremely difficult for mining companies to retrench the workforce as part of cost cutting measures.
- **Namibia:** Namibian regulators are reconsidering the Foreign Investment Act and the Namibian Equitable Empowerment Legislations (NEEEB). While these regulations are not specific to the mining industry, mining companies operating in Namibia will be affected.
- **Malawi:** For a long time the mining sector in Malawi was not very active. Recently, due to the active nature of the mining sector, there have been several amendments to the regulatory landscape. For example, a major amendment in 2017 was the inclusion of a "Sixteenth Schedule" regarding the "Taxation of Mining Projects" in the Taxation Act of Malawi.
- **Ivory Coast:** Ivory Coast recently introduced investor friendly legislation to try to position themselves as an alternative mining investment destination.
- **Tanzania:** The mining sector in Tanzania is coming closer to total nationalisation. Current developments in the mining industry in Tanzania include the Natural Wealth and Resources (Permanent Sovereignty) Act No. 5 of 2017, The Natural Wealth and Resources Contracts (Review and Re-negotiation of Unconscionable Terms) Act No. 6 of 2017 and the review of the declarations and reporting in the extractive industry with beneficiation, environmental rehabilitation and the necessity for mining companies operating in the jurisdiction to listed on the local stock exchange being key trends.

Embracing Technology

Like other industries, the future of mining policy and regulation is heavily influenced by global movement toward digital transformation, and broadening value creation to delivery socio-economic impact alongside shareholder value.

Technology can enable better management, monitoring and reporting on both regulatory and policy changes, as well as compliance levels. Mine operations can benefit through:

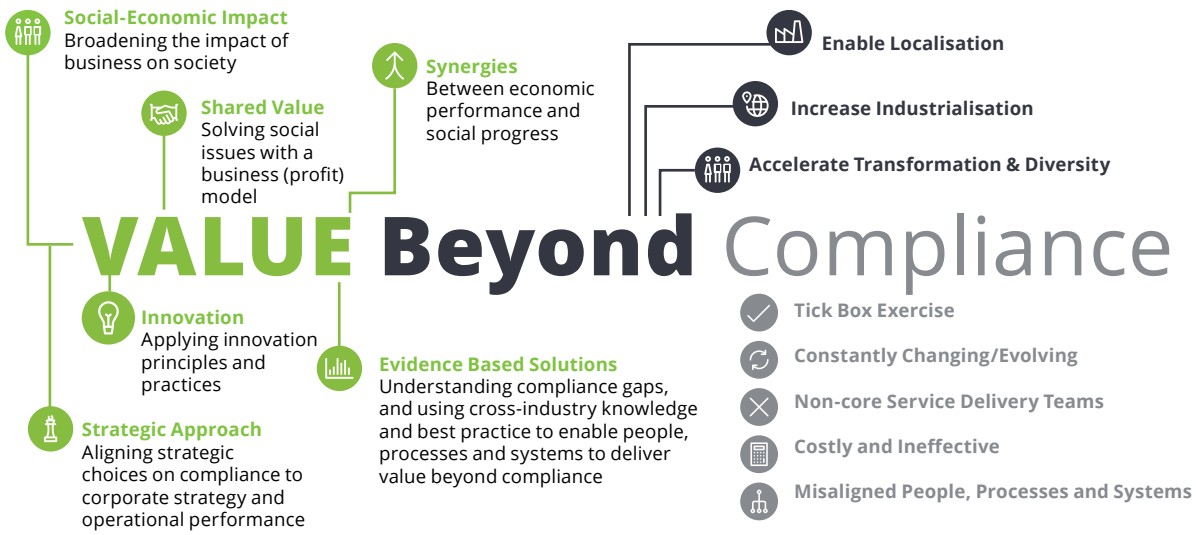
- Undertaking a regulatory and policy landscape assessment, optimising around overlaps, compliance gaps, and the technology and tools available to manage and monitor landscape changes and compliance levels
- Creating a centralised repository to ensure the quality of regulatory content is kept current and maintained
- Automating reporting, with ease of monitoring through the likes of dashboard views, to improve accuracy, reduce human interaction, and provide all relevant stakeholders with real-time data and analytics on compliance requirements and levels
- Providing the C-Suite with the ability to assess compliance challenges as they occur, to expedite strategic change as is necessary.

Creating Value Beyond Compliance
As compliance measures and targets progressively increase across various industries and sectors, and social and developmental pressures persist, changing ways of work to move away from a 'tick-box' compliance mindset is critical. Delivering **value** beyond compliance requires that mine operations:

- Fully understand the impact of compliance changes and their gaps to compliance
- Align the changes and gaps in compliance to their corporate strategies and operational performance, leveraging cross-industry best practice
- Leverage compliance requirements to maximise on the socio-economic impact possible, to deliver value beyond compliance.

Defining Value Beyond Compliance:

Through industry and technical expertise, Deloitte assists mining clients in navigating their compliance landscape, in a manner that moves beyond compliance, and enables increased socio-economic impact, improved business and operational efficiencies, and sharing of value within a mine's operating ecosystem.



Shared Value and Socio-Economic Effects

While the 4IR brings some challenges, it also opens up a range of choices for mining companies to create shared value and economic benefits for the communities in which they operate.

Introduction

Mines are likely to adopt digital innovations to not only improve safety, operational efficiency and profit margins; but also remain competitive. The number of jobs mines create, and cut, remains a key focus point for companies, national governments, communities and trade unions. In many instances, adopting digital technology reduces the human input required, and in the minds of many role players, there is an immediate assumption that it will lead to increased mining job losses, and a negative socio-economic impact for communities dependent on mines for economic opportunities.

Nevertheless, it is important to be cognisant that mining companies have choices in shaping the new future brought on by digital disruption. By adopting a shared value approach, the 4IR is not necessarily a zero-sum game where mines win and communities lose, rather an opportunity for greater socio-economic impact.

Impact of digital disruption

Navigating socio-economic choices posed by the 4IR will be challenging in the context of Africa and South Africa. The World Economic Forum expects digitalisation to displace jobs across all industries, with estimated losses anywhere from 2 million to 2 billion.

The net effect of digitising operations is a potential loss of low-skilled labour. Routine, repetitive jobs are most at risk, likely affecting both middle-income and lower-income employees who perform low complexity tasks.

In mining, digitalisation will likely impact both the number and nature of several job categories, and in the industry as a whole, future net job losses are expected. Given the nature of mining, and its role in Africa's emerging and developing economics, automating low-complexity tasks will not only affect company bottom lines but also potentially exacerbate socio-economic conditions in countries with high levels of unemployment and insufficient levels of economic growth.

The 4IR could also pose other socio-economic challenges on a macro level. Talent will outweigh capital as a critical factor of production, further giving rise to a segregated job market of 'low-skill/low-pay' and 'high-skill/high-pay' segments; which in turn may lead to greater social tensions already prevalent in mining communities across the continent.

Finally, a greater increase in the wealth gap may fuel these tensions further. History has taught that the largest beneficiaries of innovation tend to be the providers of intellectual and physical capital – the innovators, shareholders, and investors[3], often leaving middle to lower income communities behind. 4IR however also provides opportunities for society and the economy. Digital disruption may well lower the threshold of access to many of the core elements of a decent standard of living. Looking at the precedent created by previous industrial revolutions, it holds a promise that quality of life and income is likely to improve across the globe.

Digital technologies could provide the means to address social and economic inefficiencies in communities, stimulate local economic growth in the ecosystems where mines operate and build self-sustaining communities that weather tumultuous times.

Shared-value framework

To address the challenges laid out, a new socio-economic framework is necessary. Shared value provides such a framework to make positive gain, win-win choices where societal role players, such as mines, their communities and local government, share an interdependent future. The key premise of shared value is that the competiveness of a business and the health of the community in which it operates are interwoven. Through business decisions, policies and practices related to products and services, supplier and local economic cluster development, a company is able to advance the economic benefits and social conditions of its communities while simultaneously enhancing its own competitiveness."[4]

Choices to leverage digital disruption

Digital disruption and technology are tools that can be wielded to achieve dramatic change within the socio-political landscape and enable local cluster development. To do so, mining companies and other role players must recognise their responsibility to make choices as to its implementation. Essentially, the extent to which 4IR will have an impact on mines and their communities, is a choice facing both business and government.

[3] www.weforum.org, Accessed November 2017

[4] Michael Porter and Mark Kramer, "Creating Shared Value", Harvard Business Review, 2011

The digitalisation choices posed to companies and governments affect almost every dimension of socio-economic wellbeing, correlating with policy priorities across the continent, including for example South Africa's National Development Plan.

These choices should not be considered in isolation, but are best approached collectively by mines, government and communities to inform digital strategies from a shared value perspective.

From job losses to education

Direct employment does not constitute the only impact where a mine has agency to influence a community's economic livelihood.

Digital disruption has been lowering historical barriers of access to education with online learning platforms that provide valuable and useable skills development. Through the reach of digital technologies remote locations no longer require local expertise to transfer educational or specialised knowledge.

Open education gives unprecedented access to high-quality educational experiences and resources. Frameworks in this space include:

- Open Educational Resources (OER) with no cost access
- Massive Open Online Courses (MOOCs), designed for "large numbers of participants that can be accessed by anyone anywhere[5]
- Self-Organised Learning Environments (SOLEs) which reduce reliance on a traditional teaching environment
- The Massachusetts Institute of Technology's Scratch and Microsoft's Micro:bit, which offer affordable opportunities to learn coding and adopt the thinking that underpins the 4IR technologies.
- Through 4IR, community oriented education projects become more affordable, create impact and lend themselves to collaboration.

New skills development

Education platforms are enablers to meet the demands of a new skillset paradigm brought on by 4IR.

Job skills requirements (locally and globally) are not only shifting towards Science, Technology, Engineering and Mathematics (STEM), but also to the ability to more effectively empathise with other human beings; resulting in a collective skillset coined by Thomas Friedman as STEMpathy.

An increased demand for STEMpathy-enabled individuals across the globe presents an opportunity for investment in local skills development to cultivate 21st century skills. These include intangible skills such as EQ, curiosity, creativity, critical thinking, adaptability and resilience; and skills required to work with data and algorithms. The latter will become important for mining, and other labour forces, in the short to medium term as companies adopt autonomous operations, rethink business processes using AI capabilities/ augmented and virtual reality and use predictive analytics for real-time insights. The former play a role in the future workplace characterised by connected communication and the need for a flexible, agile and collaborative workforce.

To develop a pipeline of future skills, Africa's educators should begin by encouraging critical thinking, creativity, cognitive flexibility and emotional intelligence, as opposed to rote learning, to match the way people will increasingly work and collaborate in the 4IR.

[5] http://eadtu.eu/documents/Publications/OEenM/Institutional_MOOC_strategies_in_Europe.pdf

Shifts in education and skills development provide mining companies with an opportunity to reskill employees as technology is deployed, and invest in skills development in surrounding communities; thereby addressing the deficiencies and strengthening local clusters over time.

Enterprise and supplier development

Similarly, mining companies should take a broader view of their scope of influence within the value chain by strengthening suppliers and developing enterprises within their local economic clusters.

The 4IR provides advances in technology that can create entirely new business opportunities, while enhancing route to market for suppliers in the region.

Digitalisation brings various opportunities to create shared value:

- Partnerships with original equipment manufacturers (OEMs) via digital platforms to localise maintenance of critical mining equipment
- Shared tender platforms for suppliers allowing both vendors and customers to better streamline information and opportunities in the procurement space
- Localised electricity access may allow for reductions in the cost of solar electricity generation and storage
- Conversion of abandoned mining sites into new enterprises, including solar electricity production
- Localised water purification, given reduced costs in the required technology
- Agricultural stimulation, including increased access to information, affordable digital monitoring devices and reduced initial investment.

Digital infrastructure

The Fourth Industrial Revolution also creates an opportunity to build and improve the digital infrastructure within local economic ecosystems of which the mines form part, improving the quality of life and creating conditions necessary for supplier and enterprise development.

Digital infrastructure is a key enabler of cluster development, a key entry-point for education and local enterprise initiatives.
Internet access is the first inhibitor to digital inclusion, and subsequently a fundamental prerequisite for many of the benefits that arise from the digital era. These benefits include:

- Economic benefits such as those for small and medium enterprises where it leads to increased revenue, lower costs, higher productivity and net job creation – creating conditions for improved enterprise development
- Accrued social benefits through healthcare and social inclusion (regional and national)
- Education benefits by enabling autonomous reskilling as individuals are empowered to develop on their own
- Public internet access is gaining traction in several African geographies, with a variety of funding models implemented

Establishing digital infrastructure should be a shared priority of business, government, institutions and service providers within an ecosystem. The decreasing cost of infrastructure required to engage children from a young age, through exposure to digital technologies and available education environments, makes these investments increasingly appealing and affordable across a range of socio-economic development choices.

Cyber Risk

With the advent of the digital revolution, cyber risk has become pervasive, resulting in many Boards and Risk Committees listing it as one of their top five risks.

Introduction

Cyber risk and its potential effect on commercial operations has been a Board-level consideration for a number of years. As the risk has become more pervasive and widely publicised in the media, mining organisations are beginning to garner a better understanding of the potential impact that it poses to mining operations. As many mining organisations are underway or embarking on digitalisation of their mining operations and with convergence of the traditional information and operational technologies (IT & OT) their cyber risk is increasing with their increased cyber footprints.

Mining industry operations are largely reliant on automated industrial technology or Industrial Control Systems (ICS), also known as Operational Technology (OT). Reliance on this infrastructure has highlighted the criticality of the availability, resilience, and safe operations of the infrastructure. Consequently, ICS infrastructure is one of the industry's cyber security focal points.

Better understanding of the impact that cyber risk poses to mining operations has led to a more proactive management approach.

Legacy cyber risk challenges in the mining industry

Part of the mining technology legacy stems from ICS that was far less connected to the Internet and into the IT environment. At present, the benefits of operations insights, optimised strategic and tactical planning, equipment maintenance and value chain management is driving a much more interconnected ICS environment. In the past, many mining organisations have suffered a false sense of security, perhaps even complacency, resulting from their investments in non-agile security tools and processes that they have relied on for years. Yet firewalls, antivirus, intrusion detection and prevention systems (IDS/IPS) are increasingly less effective as attackers employ encryption and other innovative techniques to evade them. Many companies have failed to detect longdwell cyber-intrusions in both their IT and OT environments and misallocated limited resources to lesser, more generic threats.

This has presented a challenge for mining companies as connected and networked IP and telemetry devices present ripe hacking opportunities for cyber-criminals. Deliberate attacks of this nature may result in the manipulation of machinery and or vehicles for the purposes of causing catastrophic failures or shutdowns of entire production plant processes and raw material extraction. Hacks of this nature in the mining industry may result in loss of life, resultant poor labour relations, regulatory issues, mine stoppages for purposes of investigations, loss of revenue and reduced business performance.

Sector specific cyber risk to the mining industry

Cyber criminals may be well-resourced and potentially even nation-state sponsored. They can be highly capable, methodical, and patient – and their tactics keep shifting. Adversaries can gain undetected access and maintain a persistent, long-term presence in critical IT/OT environments, operating below the radar of the mining organisation's cybersecurity team.

Closer inspection of the cyber-attacks executed globally against the mining industry have illustrated that the following threats are most prevalent:

- **Insider threats:** Individuals in the organisation who have access to company information, who maliciously exfiltrate or intentionally sabotage data for purposes of personal financial gain or on-selling of the data.
- **Corporate espionage:** The theft of exploration data or sensitive financial information, often used for purposes of insider trading. The theft of process information and ICS equipment configuration files and specifications is also part of the corporate espionage tactics used to further the commercial interests of competitors or third parties.
- **Hacktivism:** Individuals or groups who execute cyber-attacks for purposes of effecting social change. This can include environmentalists, socio- and geo-political organisations.
- **Data manipulation:** These attacks have been comprised of Business e-mail Compromise (BEC), which is the fraudulent use of e-mail communications to swindle personnel into paying over large sums of money, disclosing sensitive information, or even having product delivered to non-existent entities.

The digital mine, future of work and collaborative strategies

The digitalisation of mining has created an infrastructure of networked hyper-connectivity linking every aspect of the mining operation. This level of connectivity has created a very dynamic 'future of work', and cyber risk landscape in the mining industry.

The creation of the digital mine has resulted in big shifts away from traditional mining technology, the nature of resources needed to manage that infrastructure, and new and innovative 'ways of working'.

This complex risk landscape and requirement for a new way of working has also necessitated operating in an ecosystem of collaboration and unorthodox partnerships for purposes of both securing the digital mine and driving the industry forward. Collaboration for purposes of managing cyber risk has become an absolute necessity.

Collaborative ecosystems have at times proven to be a challenge to accomplish. This comes about primarily due to the existence of barriers like reluctance to trust, concerns around sharing of intellectual property, and challenges around sharing data and different speeds of technology change in the IT and OT environments. Due to the global nature of cyber risk, working within a collaborative ecosystem is more important than ever before.

Leading collaborative strategies include:

- Turning cyber security vendors (OEM's, System Integrators, etc.) into partners who hold a shared interest in your cyber security
- Collaborating with competitors and peers in the mining industry
- Building extended partnerships with mining peers, vendors, and supply chain stakeholders.

Executive-level risk oversight

The Board and senior management in their capacity of overseeing risk management activities and monitoring management's policies and procedures play a significant, strategic role in overseeing and thoroughly interrogating prevention and response to the cyber threat.

Boards are including cyber risk as a regular and important agenda item (often as a "Top 5 risk") and are mandating existing sub-committee's (e.g. Risk, Audit, etc.) or even establishing dedicated sub-committees to oversee management and response to this risk.

Ten key questions to ask about cyber risk at every level of management

01. Do we demonstrate due diligence, ownership, and effective management of cyber risk?
02. Do we have the right risk leadership and organisational talent?
03. Have we established an appropriate framework to escalate cyber risk, and does this include our risk appetite and reporting thresholds?
04. Are we focused on, and investing in, the right things? If so, how do we evaluate and measure the results of our decisions?
05. How does our cyber-risk programme and capabilities align to industry standards and peer organisations?
06. Do we have a cyber-focused mind-set and cyber-conscious culture, organisation wide?
07. What have we done to protect the organisation against third-party cyber risks?
08. Can we rapidly contain damages and mobilise response resources when a cyber incident occurs?
09. How do we evaluate the effectiveness of our organisation's cyber-risk programme?
10. Are we a strong and secure link in the highly connected ecosystems in which we operate?

Concluding Thoughts

With incredible opportunities in the 4IR and the challenges these opportunities bring, the future is now. Those who are prepared will successfully navigate a revolution.

The pace of digital change and the advent of the fourth industrial revolution has come to bear in the mining industry. Innovations will not only improve safety and operational efficiency but become a cornerstone of future competition through automation and disruptive innovation. Regulatory changes further demand that this innovation is balanced within the socio-economic environments that mines operate. To strike the balance correctly for a future fit mine, there are three domains that mining executives need to consider:

1. **Emergent opportunities:** the business evolution that is the digital mine opens opportunities in core mining operations, the flow of information, and supporting processes; whereas the changes and new demands for the workforce in the type of work undertaken in the workplace will define the future of work.
2. **Regulatory shifts:** ensuring that value is driven through compliance by realising inclusive growth, skills development and supplier development, while seamlessly monitoring and adopting regulatory changes.
3. **Impacts:** the changes brought by emergent opportunitites and regulatory shifts will impact the labour force, communities and environment, and therefore adopting shared-value thinking in the socio-economic sphere and readying the organisation against risks from a digital future, including cyber risk are paramount.

Embracing a digital future does not need to be a daunting task. Those organisations who prepare appropriately and take disciplined, agile approaches to defining a digital change transformation and impact undertaking will be fully prepared for the future. The up side in both efficiencies and social integration for the winners will be significant – and they will become the industry leaders of the future.

Contacts

Overall

Andrew Lane
Africa Energy & Resources Leader
alane@deloitte.co.za

Rolf Moes
Monitor Deloitte
rmoes@deloitte.co.za

Contributors

The Digital Mine

Philip Raw
Monitor Deloitte
praw@deloitte.co.za

Jan-Adriaan du Plessis
Strategy & Operations
janduplessis@deloitte.co.za

The Future of Work

Belinda Booyens
Human Captal Consulting
bbooyens@deloitte.co.za

Frik Snyman
Human Capital Consulting
fsnyman@deloitte.co.za

Regulatory and Policy

Stelio Zakkas
Monitor Deloitte
szakkas@deloitte.co.za

Alex Gwala
Tax
agwala@deloitte.co.za

Verosha Naidoo
Tax
venaidoo@deloitte.co.za

Shared Value and Socio-Economic Impact

Shani Cronje
Monitor Deloitte
scronje@deloitte.co.za

Cyber Risk

Tiaan Van Schalkwyk
Risk Advisory
tvanschalkwyk@deloitte.co.za

Cathy Gibson
Risk Advisory
cgibson@deloitte.co.za

Deloitte.

Designed and produced by Creative Services at Deloitte, Johannesburg. (814264/mar)