

Is riding the digital wave key to wiping out your competition?

Mining and metals



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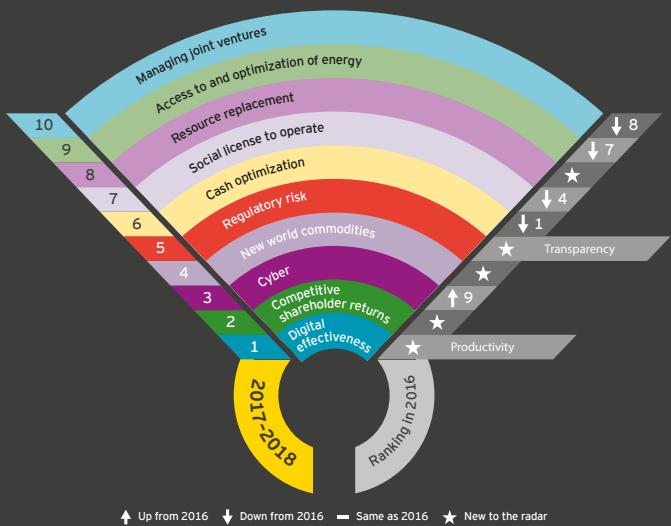


Building a better
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Digital mining: the next wave of business transformation

In our recently released report *Top 10 business risks facing mining and metals 2017-2018*, we identified digital effectiveness as the number one risk facing the mining and metals sector. The growing disconnect between the potential of and the successful delivery from digital transformation has been a common theme in a number of our recent publications and webinars. Given that digital has been identified as a critical enabler to address the sector's productivity and margin challenges, it is important that organizations develop a clear approach to bridging the disconnect.

Top 10 business risks



This paper is intended to explore in more detail a pragmatic pathway for transformation, and specifically to describe a structured “wave” approach, which can start to integrate different digital initiatives into a more cohesive whole.

Specifically, we would like to address the following questions:

- ▶ What is the appropriate digital end-state to target for your organization?
- ▶ What are the next steps based on the nature of your business and your digital maturity?

We will also present some case study examples to demonstrate the proposed approach along with directly addressing the questions that senior mining leaders are asking, such as the impact of digital on workforce numbers, the best organizational structure for implementation and the importance of cybersecurity.

Improving digital effectiveness

As leaders, we are subject to seemingly endless exhortations to get on the “path to digital enlightenment.” The claimed size of benefits from digital is large, but often the supporting logic lacks the rigor expected for significant business investment. There are numerous articles describing the rise of artificial intelligence (AI), automation, data analytics and the risks associated with cybersecurity; but the current market maturity only offers solutions that address just parts of the value chain, and not its entirety.

Point solutions are appearing in areas as diverse as how we maintain our assets, train our people, respond to disruptive weather events, sell our commodities, keep people safe, reduce working capital, optimize our production plans, integrate across value chains, and automate contractual processes through the introduction of technologies such as blockchain.

Despite this, improving digital effectiveness still faces significant challenges such as:

- Maintaining business continuity while transitioning from legacy systems
- Managing the workforce skill mix to facilitate organization competency in a digital world

- Choosing new business partnerships in, for example, analytics and automation, which may be outside the traditional mining sphere
- Getting the balance right between the risk of introducing new technologies and maintaining future competitiveness
- Finding cash to invest in the down cycle and avoiding business disruption when margins are strong

Compounding these issues is the sector's historically siloed approach to productivity. Digital solutions are being adopted, but usually as point solutions in the value chain rather than as a holistic approach as discussed in our paper *How do you prepare for tomorrow's mine today?*¹. Point solutions will not get us to the next level of productivity improvement or enhance end-to-end decision-making.

The collective impact of these challenges can result in a tentative approach to strategy – reflected by small, disconnected initiatives – rather than a strong commitment to a multi-year or “digital wave” transformation approach. This view is reinforced by a recent EY desktop review that identified around 60 mining-specific digital themes and accompanying initiatives in the sector, but relatively few examples of a clear, integrated business-wide approach.

The productivity paradox

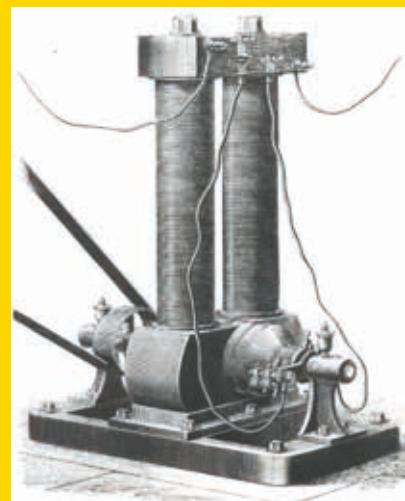
In 1990, Paul David wrote a seminal paper¹ investigating the apparent paradox wherein the introduction of a manifestly better technology is slow to produce the expected productivity benefit. His article, focusing on the early years of digital computing, draws parallels with the introduction of the electric dynamo in the early 20th century.

Some of the factors driving this “productivity paradox” were:

- Initial high cost due to lack of scale

- Cost of replacement of legacy plant
- The “overlay of one technology on a pre-existing stratum” resulting in decreases in performance from both systems
- Lack of capability to recognize and implement new business models, which results in the old model being operated with underutilized new technology

All of these factors can be seen in the current digital transformation challenge facing the mining sector.



¹ Paul David, “The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox,” *The American Economic Review*, Vol 80, No 2, May 1990.

¹ *How do you prepare for tomorrow's mine today?* EYGM Limited, 2017.

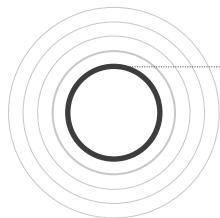


EY's wave approach to digital transformation

In considering the best approach to transitioning a business from the current state to an improved future state, we have identified what we believe to be a sensible pragmatic approach. This approach meets the need of having an active, progressive and compelling digital strategy, while also recognizing the issues associated with business risk and maintaining a coherent program of work.

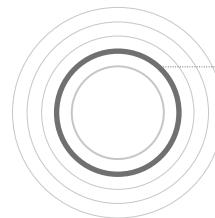
A large mining company does not have the freedom of a start-up business in terms of avoiding the challenges of, for example, legacy systems or an entrenched culture. As such, we believe that a clean sheet or revolutionary approach to digital would be overly disruptive to cash flow and would trigger reasonable concerns from boards and shareholders. We would, therefore, recommend a series of waves moving through the organization, steadily introducing more digital hotspots and interconnections, all within a coherent overarching strategy.

This wave approach to digital transformation contains four main components:



Digital pre-start

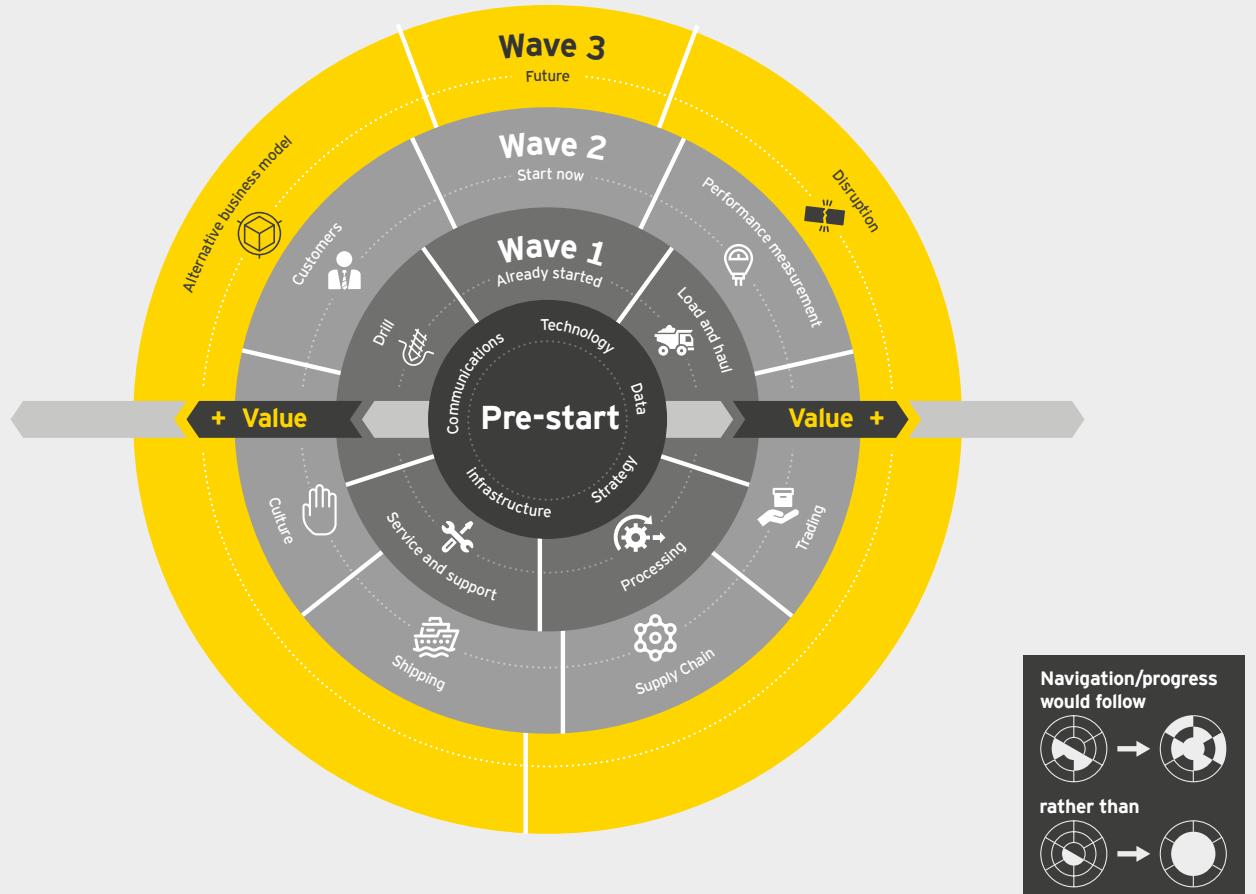
Digital pre-start covers work such as establishing a clear vision, creating a linkage between productivity and your digital agenda, and understanding your current digital maturity. A minimum investment in infrastructure and data availability needs to be in place to enable an organization to make an effective start on Wave 1 activities. This may mean that your key assets need to be connected from a data visibility and monitoring perspective, but not necessarily all possible parameters of that asset are available, e.g., conveyor velocity is required but vibration is not. It is critical at pre-start to set up stretch measurable goals (KPIs) so that the vision is grounded in tangible targets and the program's effectiveness can be measured throughout each wave.



Wave 1

Wave 1 activities will add business value through local optimization or automation. Generally these initiatives will not require a change in your existing operating model and won't in themselves be transformational. They will start the process of transformation without having to manage a web of complex organizational interactions or by introducing unacceptable levels of business risk. This is not to say that Wave 1 work should be siloed or ungoverned – instead, the work must be carefully prioritized, linked to the productivity agenda and selected with a view to integration during the next wave.

We see many of the technologies and processes within Wave 1 being available for implementation within the next 18 months – indeed there are many initiatives already being actively pursued in the sector. In some cases, projects would have been implemented in your business but might have been stalled or under-delivered due to reasons such as insufficient resourcing, lack of the right capability within the organization, or poor integration within your current operating model.



Wave 2

Wave 2 activities involve significant changes to your operating model or potentially disruptive process changes across organizational boundaries. For example, businesses moving to a fully predictive maintenance domain, supply chain operation without human controllers, blast design and concentrator process control integrated and automated, or real-time mine planning linked to equipment health and commodity pricing. On the sales and marketing side, Wave 2 activities may include the use of predictive analytics on customer buying behavior or market information, and optimization tools to drive improved profitability matched to production output.

We currently see relatively few examples of Wave 2 activities in the mining and metals sector and believe that, while many of the required technologies exist, successful application in an industrial setting will continue to require significant development effort over a multi-year horizon. Similar to the situation described in “The productivity paradox” sidebar, the real value from digital will arise only when we reach the phase of genuinely changing how we work, rather than only pursuing local optimization and automation, which is valuable, but not necessarily transformational.

Wave 3

Wave 3 are the “disruptive” factors that may create significant changes in how the sector operates and require a step change in business strategy to maintain competitiveness. While we don’t believe there will be an Uber or Airbnb type disruption, the opportunity for new entrants to disrupt existing players is real. As we saw in the oil and gas sector in the 1970s, under the right conditions, key service providers can control significant portions of the value chain in the industry. Schlumberger and Halliburton have enabled a shift in profit and market power to state-owned companies due to their ability to offer more affordable and integrated approaches across the entire value chain. In the mining market, a similar structural change in the industry could be a disruption scenario. There is an advent of new and disruptive technologies in the sector. New players could be more willing and abler than the existing players to invest capital in these currently untested technologies, which would enable innovative business models to drive a new wave of productivity uplift across the value chain. Other examples of disruptors may include changes in how we consume and recycle, geo-political instability from a shift in global labor dynamics, resource nationalism, and through the ethics of introducing AI to particular applications. Wave 3 changes are not always readily apparent from our current day perspective – the future of the sector will continue to evolve in ways that may not be easily predicted.

As we have observed in other sectors, market leadership can quickly be lost as dominant players respond slowly or ineffectively to industry disruption and external changes. To best prepare for this, mining companies should employ formal strategy reviews, which scan for trends in the operating environment and develop appropriate response strategies.

An important characteristic of the wave approach is that suitable pathways for different businesses will depend on their primary

drivers of business value. For example, a business with a heavy reliance on asset reliability may wish to focus on predictive analytics to improve equipment uptime. Another business, where value is driven by supply chain efficiency, may be looking to pit-to-port simulation and decision support tools as part of Wave 1.

Another key wave characteristic will be the digital maturity of a particular business. For example, some global mining organizations may already be a long way down the path with



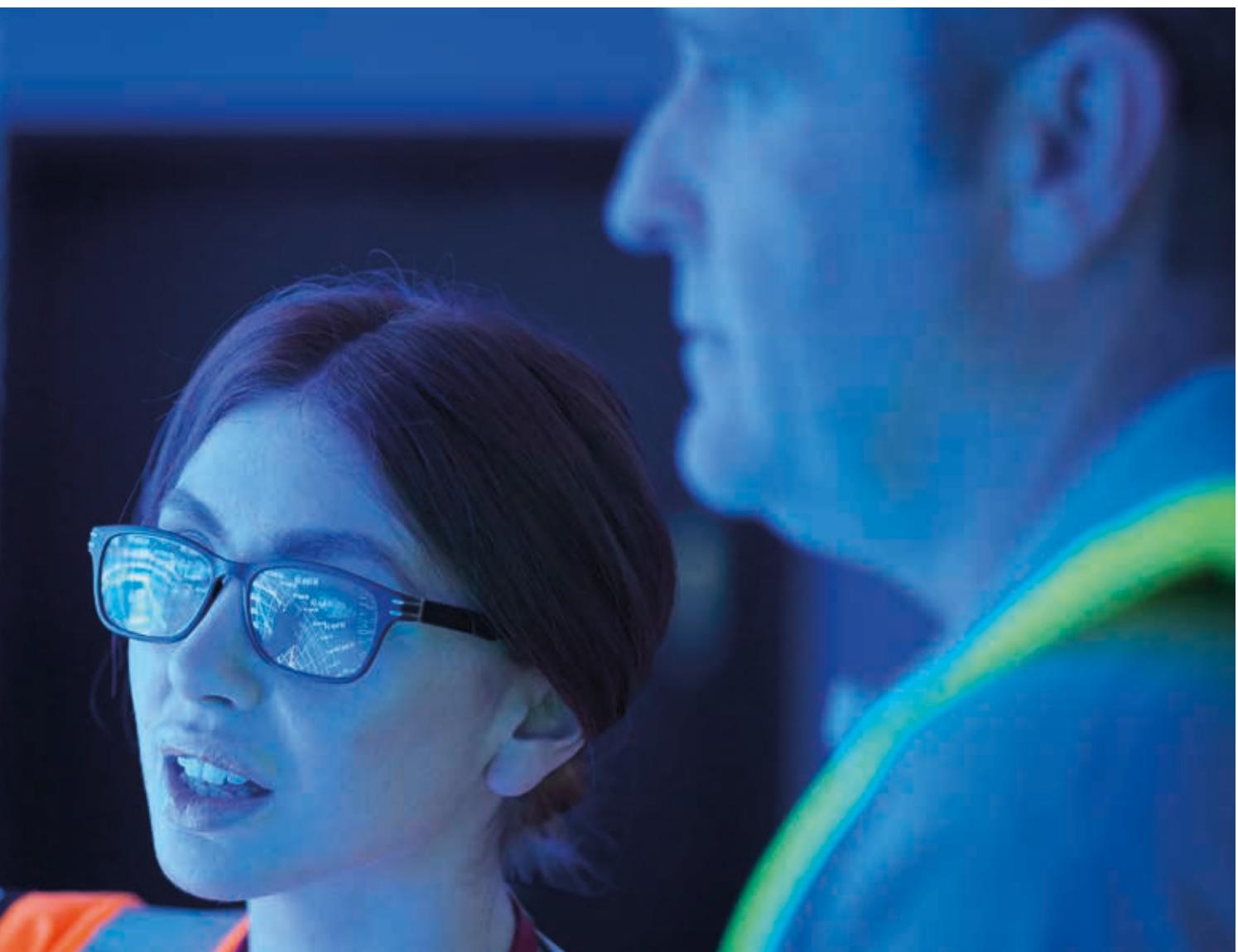
various Wave 1 initiatives and would now be considering how to approach Wave 2 – integrating the activities to drive beneficial changes in their operating models. Less-mature organizations may need to focus on more “entry level” analytics and data visualization.

Two other important elements to note:

- ▶ The pathway through the waves cannot be viewed as static or “set and forget.” We see the end-state vision as constantly

changing and businesses will need to be ready to adapt and change course as required.

- ▶ The process of launching waves is not necessarily sequential. For example, high-value areas with a close link to productivity may move from Wave 1 to Wave 2 before initial work has commenced in areas with less-compelling business cases.





EY's wave approach to digital transformation

Digital pre-start

Establish your digital vision. Confirm that your senior leadership team owns a shared vision consistent with business strategy.

Understand your business levers and how they will drive productivity.

Match digital opportunities to high-priority areas.

Complete a Digital Maturity Assessment to understand organizational capability. Assess what competencies are needed to support transformation and whether they exist in your organization. Determine areas where skills need to be developed internally and areas where you should partner externally.

Establish transformation governance covering elements such as project management, organizational accountability, data architecture, and business case development.

Have long-term data architecture design in place. We don't advocate waiting for the data to be "perfect," but it is important to have a clear data strategy. In the order of preference, focus on the opportunities to use existing data, and remediate current databases and potential sources of new data.

Have an appropriate cybersecurity strategy in place to keep pace with your transformation. Getting too far down the transformation pathway without a fit-for-purpose cyber strategy can lead to costly rework.

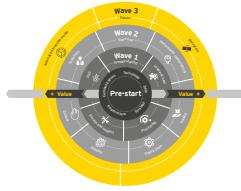
Have a process to drive a regular refresh of your digital strategy in response to an evolving landscape.

Wave 1 (Already started)

The specific nature of Wave 1 activities will be dependent on business maturity and the productivity value drivers. The following list shows the type of local optimization and automation opportunities that could be pursued:

- ▶ Introducing predictive analytics to provide better warning of component failures; developing a predictive analytics strategy
- ▶ Tuning up existing fleet management systems to help them to deliver their potential
- ▶ Updating and fully digitizing maintenance tactics
- ▶ Assessing opportunities for digitizing and exploiting legacy exploration data
- ▶ Considering the opportunities for exploiting your ore body more effectively through data fusion and visualization from existing data sources and by accessing new sensor data
- ▶ Developing your planning and scheduling tools (including sales) to fully utilize the existing data sources, IoT capability and current practice optimization
- ▶ Focusing reporting analytics on providing actionable information from existing data
- ▶ Assessing the potential from robust working simulation models for business-critical parts of your process

The design and implementation of Wave 1 activities must be within a clear framework and with the intent of supporting the business transformation that will be undertaken in Wave 2.



The following table brings together the different steps in the wave process with examples of the component activities.

Note the following descriptors need to be tailored for each organization's maturity and business levers.

Wave 2 (Start now)

Wave 2 is a structured approach to integrating Wave 1 initiatives into a new business operating model along with introducing new initiatives focused across the supply chain. Jumping straight to Wave 2 is generally not practical as the building blocks described in Wave 1 will not be in place or the level of organization change would be considered too disruptive. While many Wave 2 technologies may already be available, the applications listed below remain unproven in the mining and metals sector and will require significant development to realize benefits.

The following list shows some examples of potential Wave 2 activities:

- Linking dynamic optimization of both maintenance and production schedules; breaking down traditional business silos
- Using predictive analytics to underpin a change in maintenance strategy
- Integrating supply chain planning across the different nodes and responding to real-time market and production information
- Automatically linking blast designs to concentrator performance and implementing by smart charge trucks and autonomous drill rigs
- Performing automated stockyard management to optimize blending linked to sales contracts
- Providing context-dependent decision support to field operators
- Developing automated contractual processes
- Linking working capital management to asset condition information and production planning
- Digitally delivering training that is linked to monitoring of workforce behaviors
- Using blockchain to provide greater assurance of supply chain integrity (for example, conflict free minerals)
- Optimizing tools to drive greater real-time sales to match production profile

Wave 3 (Future)

The future of mining in a digital world will be a shifting target. Your business needs to be continually scanning for trends that may disrupt the sector and establish appropriate response strategies.

Future trends may include:

- Greater emphasis on recycling and substitution
- New industry sectors arising in response to consumer demand (e.g., lithium)
- Regulation in the area of AI ethics
- Geopolitical instability caused by the changing nature of work
- A skills disconnect in mining businesses
- Service companies becoming dominant in the value chain and extracting a greater share of the profit pool
- Resource nationalism
- Rapidly escalating importance of cybersecurity – the greater dependence on systems creates the potential for major disruptions
- Volatility driven by social media in regulatory environments
- A shift in the contractual or legal environment through the use of distributed ledger technologies



Bringing it together: use cases from the industry

The following graphic shows three use cases with examples of potential wave activities. These examples – aspects of which are being pursued at global mining companies – have been selected to show how valuable work can still be performed at the Wave 1 level, but will not unlock the full potential from digital until Wave 2 solutions are introduced.

The third example is related to geo-fencing, a technology that is being applied across a wide range of industries in applications such as direct marketing, asset tracking and improving workforce safety. Safety-related use cases can be found in both the mining and manufacturing industries along with other primary industries such as forestry and agriculture.



	Optimizing maintenance planning of underground assets 	Frontline mobility solutions 	Geo-fencing safety applications 
Pre-start	<ul style="list-style-type: none"> Clear understanding of current and target system OEE Asset criticality assessment completed Maintenance tactics for all critical equipment (e.g., underground conveyor belt, crushing units) documented and incorporated into maintenance systems 	<ul style="list-style-type: none"> Clear documentation of the work of the role. For example, exactly what are the outputs and tasks expected from a frontline supervisor Ability to provide information to supervisors in the field, i.e., suitable connectivity in place 	<ul style="list-style-type: none"> Map potential risk areas which have a geo-location component (e.g. speeding, human interaction with equipment, equipment-equipment interactions, unauthorized access). Identify potential vendor solutions (off-the-shelf or customised) that can reduce risk
Wave 1	<ul style="list-style-type: none"> Condition monitoring sensors installed on critical assets Analytics engines developed to provide early warning of failure Static optimization of maintenance plans between different parts of the system (e.g., conveyors, mill, crushers) 	<ul style="list-style-type: none"> Mobile checklists containing location dependent information (e.g., hazard reports) Live location information linking team locations and task (e.g., employee A is nearby, consider a safety interaction) 	<ul style="list-style-type: none"> Trial geo-fencing solution, for example, limiting access of vehicles to operating pit areas, tracking vehicle speed in restricted zones, monitoring of remote crews. Develop metrics framework, and if appropriate, disciplinary framework.
Wave 2	<ul style="list-style-type: none"> Dynamic optimization of maintenance schedules and production rates based on, e.g., analytics determining remaining life of belt, production margin, and coordination with other outages 	<ul style="list-style-type: none"> Extend mobile checklists to include variance reports, e.g., high truck queuing in Pit A requires attention or trucks on delay is above target Optimization tools that suggest changes in resource allocation (e.g., maintenance overrun, send truck drivers to crib) 	<ul style="list-style-type: none"> Extend the concept beyond geo-location to include operator competency and behaviour tracking. Further extend monitoring to track operator productivity linked back to training systems.
Wave 3	<p>Wave three transformation will typically disrupt the nature of work in a material way. For example, a traditional underground block cave may be replaced by in situ processing. In a Wave three operation, the "frontline" supervisor may operate completely remotely with largely automated equipment. Decisions may be made by an Artificial Intelligence engine which looks to optimize across a wide array of sensing inputs.</p>		

As mentioned in the introduction, a recent desktop review of current digital initiatives in the mining sector identified around 60 themes that would predominately fit the category of Wave 1 activities – a clear evidence that the pace of digital change is

building. The proliferation of activity reinforces the importance of having a structured program rather than succumbing to the lure of technology change, which is not linked to the productivity agenda and capability of our business.



Digital pathway: frequently asked questions

In previous publications on digital transformation in the mining and metals sector, we have identified that assessing digital solutions and managing a program of work require different skills from senior leaders compared with driving more “traditional” mining work. To assist in the process of building an understanding of the requirements of digital, we have developed some frequently asked questions and the EY view on how best to address particular issues.



How can I start embracing digital while maintaining agility and not over-investing?

The approach we recommend is no different to traditional project management. Make sure that the strategy is sound and supported by a clear vision. Think of appropriate phasing and milestones. Establish that the investments are backed by clear business cases tied in with value drivers. Consider the cultural implications of change and engage the right stakeholders in your business.



How do I best manage the cybersecurity challenge?

See sidebar.



What will the impact be on my workforce?

In some areas – for example, haul truck operation or financial reporting – we believe that the introduction of greater levels of automation will lead to inevitable job losses for particular occupations. This is in line with broader societal trends moving from manual tasks through to a more information-focused global labor force. There is the opportunity for businesses to upskill or reskill employees to establish the right balance between not completely losing existing in-field knowledge while leveraging the benefits of automation and real time data usage. Organizations can shift the focus of work toward improved decision-making and efficiency of execution. For organizations in countries operating in more constrained industrial relations environment, it will be important to engage with regulatory authorities to respond to the changing nature of work. The impact on the workforce will affect the local community so it's important for organizations to work with these communities to manage this shift.

Cyber risk

Our report, *Top 10 business risks facing mining and metals 2017-2018* identified cyber as the third biggest risk facing mining and metals organizations.

Cyber threats are growing at an exponential rate globally with more than half of energy and resources participants in EY's latest Global Information Security Survey having experienced a significant cybersecurity incident in the last year. The convergence of information technology and operational technology makes companies more vulnerable to the continued rogue activity in the sector. The “attack surface” is only getting larger with the increasing investment in digital and reliance on control systems for efficient operations. For example, a mining company will have thousands of connected devices, many in physically secure environments, such as the port, some in more controlled environments at mine sites, and others in public areas, such as railway signals.

A step change in the culture and awareness of the cyber risk within the mining and metals sector is needed to resolve the gaping hole that the “human factor” exposes to cyber resilience and preparedness. Understanding the cyber threat landscape is the first and vital foundation step in the change to improve the cyber maturity. In order to address the step change needed, mining and metals companies need to have a clear plan that forms part of their digital road map and risk management plan.

It is critical that the mining and metals sector accelerates its cyber program.

For more information, refer to our recent report, *Does cyber risk only become a priority once you've been attacked?*



What type of organizational structure do we need to manage digital?

Different options range from having a devolved accountability within operating units, a dedicated digital division, short-term project teams with senior sponsorship, through to a central PMO structure. Combinations of these options may exist in certain businesses.

The right answer for your business will depend on factors such as the organization's digital maturity, the type and number of digital initiatives being considered, and the relative importance of digital to business value. The scale, diversity and geographic spread of a business will also influence the decision. Finally, it is important to get the balance right between obtaining strong operational input and appropriate IST design when thinking through structure options.

Your organization needs to keep their eye on balancing efficient production with the need to innovate. In some instances, that may mean it is appropriate for digital innovations to take place within, next to, or outside of operating business units.

In all cases, a clear position must be taken which creates accountability, governance and drive within your business.



What capabilities do I need?

Using the existing domain and business improvement knowledge within your business is important. This should be coupled with engaging appropriate external analytical and systems knowledge.

The type of skills your business requires will be linked to your particular value drivers. For example, an asset-intensive business may wish to have skills in predictive maintenance analytics. If automation is an appropriate pathway, access to control engineers would be required. Data science may be a required competency if there is value in deeper understanding of large datasets within your business. Understanding the combination of existing skills which will remain relevant, such as plant operation, trades and maintenance, and how to blend these with advanced skills in engineering and data science will enable your business to achieve the best results.

Senior leaders must develop the understanding to distinguish between digital "hype" and practical pathways. It is critical to be able to clearly identify the capabilities needed to deliver long-term value and put a strategy in place to develop these skills. Executive level training covering the tricks and traps in operating in a digital environment would be valuable.



What are the first steps I should take?

We believe that there are a range of common activities as part of a "digital pre-start" process. These activities are focused on understanding your business levers and organizational digital maturity. Doing this work effectively will identify the right work so that your digital transformation is linked directly to business value rather than being a "toy box" initiative. Having silos pursue pet projects must be avoided; getting the balance right between entrepreneurialism and project governance will be crucial.

For example, an organization with a heavy focus on asset uptime may start with introducing predictive analytics for critical assets. Others may require the introduction of decision support systems to help with supply chain variability. Market-driven businesses may benefit most from looking at analytics to support trading decisions. When choosing these first steps, think about local optimization, but with a view on how these solutions will connect in the future.



What other organizational aspects do I need to consider to promote transformation?

In addition to the structure comments made earlier, other considerations include the following:

- ▶ Making sure that digital projects are properly resourced and not set up to fail due to wrong capability or insufficient full-time focus.
- ▶ Getting the right level of governance is important; a digital PMO is recommended to ensure that linkages between projects can be exploited and duplication avoided.
- ▶ Communication and stakeholder management approaches should be commensurate with the effort expected from a major change initiative.



Who in the mining and metals sector is doing digital well?

While there are pockets of excellence – largely in Wave 1 activities – there are no real examples of businesses changing their operating models in response to digital. Compared to other sectors, mining and metals has a “digital debt,” which needs to be addressed over coming years.



Should I outsource or drive change in-house?

Successful digital change will require a combination of both internal and external expertise. For example, domain knowledge, leadership drive and cultural change must come from within the organization. Expertise on platforms, analytics, and advances in simulation and optimization will be available externally. Given this required mix of skills, we believe that partnering is an important part of a digital transformation. The right mix between internal and external capability will change over time and be dependent on the digital maturity of your business and the technical challenges being addressed.



Don't I need to get my data right first?

Data and supporting systems are important issues to be get right. We see three streams of work: focusing on the significant opportunities available from existing data and systems; looking for remediation of data and processes associated with existing systems; taking a long-term view of how your data architecture needs to evolve to meet a future digital vision.



How can I start digital transformation without losing focus on productivity and margin or cost?

We take the view that digital initiatives should only be commenced where there is a demonstrable link to productivity and cost benefits. Sometimes this will require a long-term view; but organizations should avoid doing digital without this link to exploiting clear business opportunities.



Should we be driving change at the individual site level or from corporate?

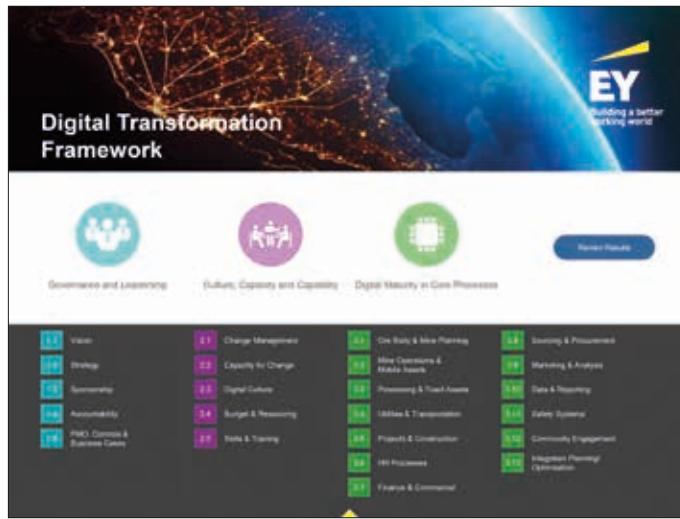
In terms of those that have digital plans, we are seeing them being driven both at the mine level and from corporate. Those that have been more successful to date though tend to be led from the top as it's really critical for the digital and corporate strategy to be hand in hand.



Closing comments

In this paper, we have explored more of the “how” to commence a digital transformation rather than pushing the “why” businesses should embark on the change. We believe that leaders are now well versed in the compelling case for change, but are looking for the right way to go about the transformation without falling into various pitfalls that cause many change initiatives to fail. It is not a question of when to go digital; it is about how to start thinking of a fully integrated business culture shift, and that really needs leadership focus. Our view is that the same rigor that underpins other major change or expenditure initiatives needs to strengthen digital transformation.

We have proposed a wave approach, which seeks to balance risk and return, and the need for rapid action but also thoughtful planning. We can support your business through the use of the Digital Navigator – an approach and toolkit that supports EY to assess a company’s digital maturity and help create an actionable digital road map for EY clients based on linking current capability and existing investments with business ambition and strategy.

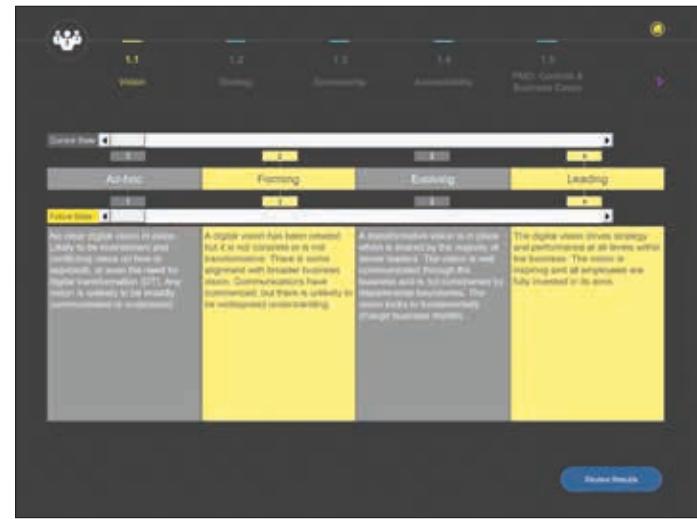


We also offer advice on the development of your cyber strategy. Our approach to cybersecurity is to apply good risk management principles – and this starts with thinking of the issue as cyber risk. We assess the situational awareness to understand the business risks, critical assets and scenarios that pose a cyber risk event. We then balance the organizational risk appetite, control

Our approach and toolkit has three phases:

- ▶ **Phase 1 – Digital vision:** The objective of this phase is to provide leaders with a compelling and aspirational digital vision aligned to the identified value or productivity opportunities with potential solutions.
- ▶ **Phase 2 – Capability assessment:** The objective of this phase is to understand the business’ ability to extract value through the proposed digital solution by identifying the key capability gaps between current state and aspirational vision.
- ▶ **Phase 3 – Embedding and transforming:** The objective of this phase is to provide a prioritized portfolio of digital solutions and an actionable, justified and achievable road map to provide maximum value. This road map is based on linking current capability and existing investments with business ambition and strategy. We provide a platform to help drive the execution of a digital transformation focused on productivity.

Using the Digital Navigator together with the Process in Mining Enterprises (PRIME) model – to assess and map digital solutions against the most critical areas of the mining value chain – aids effective prioritization of solutions and alignment for maximum release of value over time.



environment, governance and business constraints to determine a risk-based cyber risk framework and program. We believe that irrespective of the framework adopted, a risk-based approach – which is fit for purpose, adopts a balance between “protect” and “react,” and meets the operational requirements of an organization – should be taken.



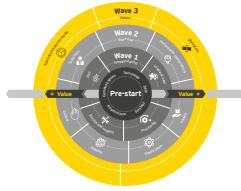
EY's wave approach to digital transformation: Checklist

Digital pre-start

- Have a clear digital vision consistent with business strategy
- Understand your business levers and how they will drive productivity
- Match digital opportunities to high priority areas
- Complete a Digital Maturity Assessment to understand organizational capability and complete a gap analysis against requirements
- Establish transformation governance covering elements such as project management, organizational accountability, data architecture, and business case development
- Have an appropriate cybersecurity strategy is in place to keep pace with your transformation
- Regularly refresh of your digital strategy

Wave 1 (Already started)

- Wave 1 activities will be dependent on business maturity and the productivity value drivers.
- Predictive analytics to provide better warning of component failures
 - Development of a predictive analytics strategy
 - Enhancement of fleet management systems
 - Digitization of maintenance tactics
 - Digitization and exploitation of legacy exploration data
 - Data fusion and visualization
 - Enhancement of planning and scheduling tools (including sales) to fully utilizing existing data sources, IoT capability and current practice optimization
 - Reporting analytics which provide actionable information
 - Robust simulation models for business critical processes
 - Design and implementation of Wave 1 activities a clear framework and with the intent of supporting the business transformation that will be undertaken in Wave 2



Note the following descriptors need to be tailored for each organization's maturity and business levers.

Wave 2 (Start now)

Wave 2 technologies listed will require significant development to realize benefits.

- Maintenance and production schedules dynamically optimize
- Predictive analytics to underpin a change in maintenance strategy
- Supply chain planning integrated across the different nodes and responding to real time market and production information
- Blast designs automatically linked to concentrator performance and implemented by smart charge trucks and autonomous drill rigs
- Automated stockyard management to optimize blending
- Context dependent decision support to field operators
- Automated contractual processes
- Working capital management linked to asset condition information and production planning
- Training digitally delivered linked to workforce behaviors
- Using blockchain to provide greater assurance of supply chain integrity (for example, conflict free minerals)
- Optimization tools to drive greater real time sales to match production profile.

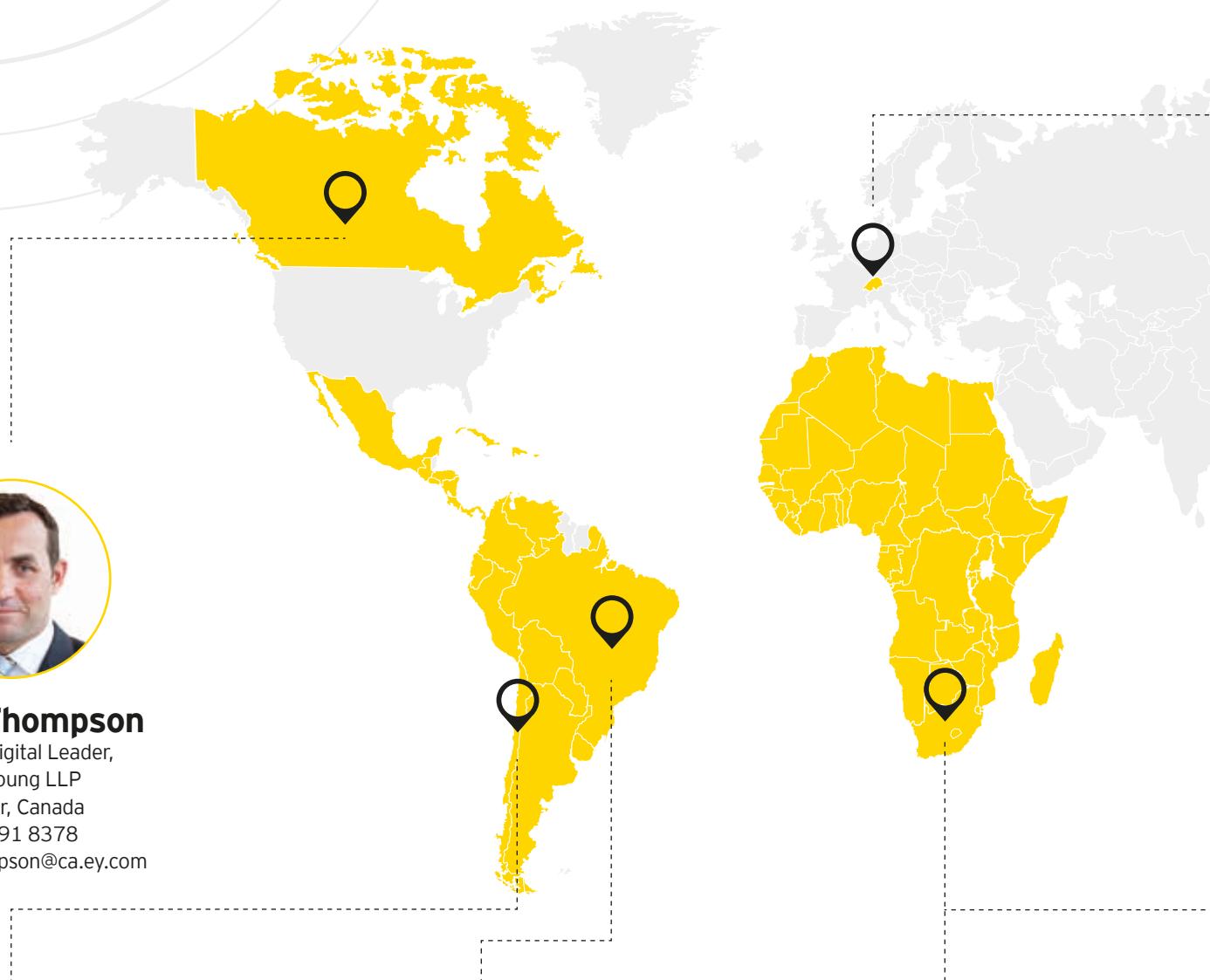
Wave 3 (Future)

Wave 3 requires scanning for trends which may disrupt the sector and establishing appropriate response strategies.

- Greater emphasis on recycling and substitution
- New industry sectors arise in response to consumer demand (e.g., lithium)
- Regulation in the area of AI ethics
- Geo-political instability caused by the changing nature of work
- A skills disconnect in mining businesses
- Service companies becoming dominant in the value chain and extracting a greater share of the profit pool
- Resource nationalism
- Rapidly escalating importance of cybersecurity. The greater dependence on systems creates the potential for major disruptions
- Social media driven volatility in regulatory environments
- A shift in the contractual/legal environment through use of distributed ledger technologies



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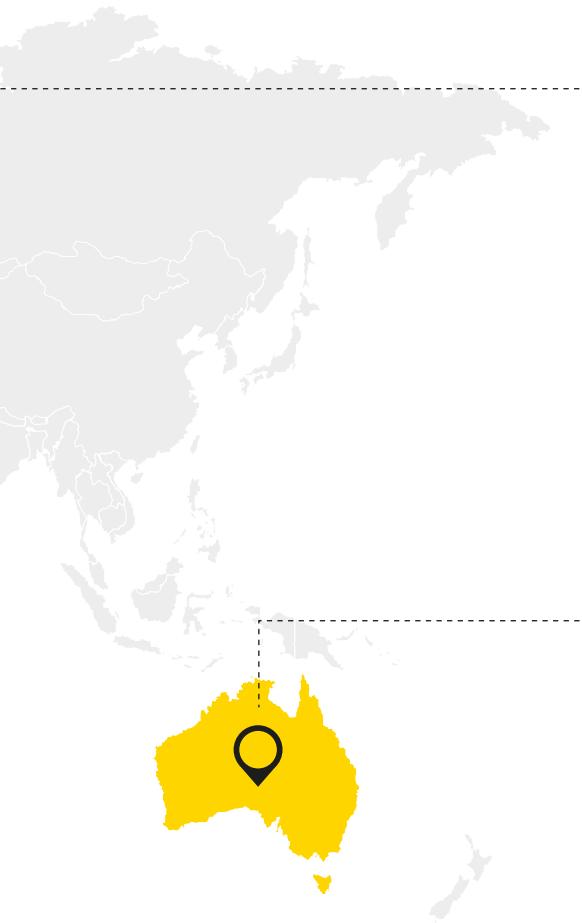
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How EY's Global Mining & Metals Network can help your business

The sector is returning to growth but mining and metals (M&M) companies face a transformed competitive and operating landscape. The need to improve shareholder returns will drive bold strategies to accelerate productivity, improve margins and better allocate capital to achieve long-term growth. Digital innovation will be a key enabler but the industry must overcome a poor track record of technology implementations. If M&M companies are to survive and thrive in a new energy world, they must embrace digital to optimize productivity from market to mine.

EY takes a whole-of-value-chain approach to support each client to help seize the potential of digital to fast-track productivity, balance portfolios and set a clear roadmap for their new energy future.

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