Successfully Implementing Technology-driven Change in the Mining Environment

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ABSTRACT

Mining has been typified of late as a boom and bust, cyclical industry operating against a steady decline in the size and quality of mineral deposits. Decreasing deposit grades and increasing costs of traditional mining techniques, all in the face of another commodity downturn, are forcing mining companies more than ever before to seek out new and innovative ways to operate. New technologies are emerging to model, control and track resources through the mining value chain, to move material about mines more efficiently, and to identify and separate ore from gangue early in the extraction process.

Discovering such technologies however is only the first challenge for mining companies. Actually implementing technological change successfully has proved to be an even bigger challenge. Like for many industries, fulfilling the promised benefits for the expense and timing envisioned, has not been easy when innovative technologies are introduced.

Citing the author's insights and experiences in a number of emerging technologies, this paper explores barriers to implementing technological change in the mining context. Key elements of a change management framework, first developed for implementing mine management systems, are described to give mining executives insight into how they and their organisations can succeed through technology-driven change.

INTRODUCTION

Beating the cycle

Mining is a cyclical industry, subject to commodity price cycles and economic cycles. To make things worse, market down-cycles now confront mining companies that are additionally challenged by the general decline in the size and quality of mineral deposits. Consequently, mining companies more than ever must seek ways to remain competitive and derive greater value from their resources, whether these are mineral, human or otherwise.

Mining companies have approached these challenges in two ways: they have cut costs and/or they have improved efficiency/productivity. Most often, these tasks are accomplished through innovation, whether this is the adoption of new processes, technology or both. This paper focuses on technology innovation – specifically implementing technological change in the mining environment.

The classes of technologies considered in this paper include:

- *mining software*: modelling, optimising, designing, scheduling, reconciliation
- *equipment management*: mine/fleet management, machine guidance, machine health
- *material handling technology*: in-pit crushing and conveying (IPCC), trolley-assist, autonomous
- *extraction optimisation*: grade control, preconcentration, process control.

Challenges in implementing such technologies are identified, as are remedies that mine management can undertake to overcome.

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Challenges in technology implementation

Implementing technological change has proven to be a challenge for organisations, and mining is no exception. Using information technology (IT) as an example, the Standish Group continues to highlight in its 2015 annual Chaos Report (Standish Group, 2015) that only 29 per cent of IT projects were successful; meaning they were on schedule, within budget, and provided the scope/quality envisioned. Interestingly, this is no different than in 2004, where the Chaos Report provided the exact same success rate (McCarthy, 2005). This underscores the difficulty in implementing technology such that, in over ten years, we still cannot get it right! In the 2015 Chaos Report, 52 per cent of IT projects were challenged to meet schedules, budget or quality, while 19 per cent failed outright.

While statistics are not specifically available, it is easy to appreciate that technology implementation has been similarly challenged in the mining industry. So why might this be the case?

In researching the implementation of fleet management systems (eg Modular Mining's DISPATCH®), the following factors have been found to negatively impact companies' abilities to successfully implement such technology (McCarthy, 2005):

- lack of senior management support
- lack of a communications plan
- not communicating to all stakeholders
- lack of attention to training
- not training all stakeholders
- leaving training at all levels to vendor
- inappropriate organisational design to accommodate the new activities and responsibilities required of the system
- lack of strong project management on client's and vendor's side
- technical difficulties with the technology itself.

A quick review of these factors (particularly the first six) draws one to the conclusion that a lack of proper change management is at the root of the challenges faced.

Mining companies increasingly recognise the importance of good change management. Gavin Yeates, Vice President Mine Optimisation of BHP Billiton, was recently quoted (Kelleher, 2015):

> *Really what we're about is change management, and people aspects are always the most challenging, rather than the technology aspects. We tend to focus very easily on technology. We're always coming up against challenging people to change, and their 'not invented here', or 'it won't work here'; those things tend to present the biggest challenges for us.*

This paper is structured to first describe the fundamentals of change management, then introduce a change management framework that was developed for implementing mining technology, and finally discuss the particular challenges of implementing technology-driven change to the mining sector and how change management has and could assist.

WHAT IS CHANGE MANAGEMENT?

Change management, project management and executive sponsorship

Change management is defined by Prosci Research, a leading supplier of change management research material, as:

> *The process, tools and techniques used to manage the people-side of a business change in order to achieve the required business outcome.* (Creasey and Hiatt, 2003, p 42)

Whereas project management deals with the technical side of a change (ie resources, budget, schedule and scope), change management deals with the people side. In change management, individuals impacted by change are helped through the process to ensure they support the change and gain the needed knowledge and skills to be successful during and after the change – all while minimising resistance.

Prosci has developed a tool called the project-change-triangle (or PCT model) for visualising the relationship among project management, change management and leadership (Figure 1). The model

FIG 1 – Project-change-triangle model with responsibilities of executives (Prosci, 2016d).

shows the connection between executive leadership and both project management and change management. On one hand, executive *decisions* connect leaders and project management, while on the other, executive *actions* connect leaders and change management. For a given change project, the model can be used to measure compliance to best practices for each of the three triangle apexes. If any of project management, change management or executive leadership is absent or reduced in the execution of a change project, the project will be challenged or will fail. By the very nature of the model, the role of executive leadership or sponsorship in change management is reinforced. Prosci has been conducting research and surveys on change management since the 1990s, and executive sponsorship is consistently one of the top critical success factors in any change. This is further elaborated below in key principles of change management.

Organisational change management versus individual change management

Change management can be approached from two perspectives: organisational change management or individual change management. Individual change management is about assisting an employee as they go through the stages of a change process. A tool that can be used for this, the ADKAR model, is described below in a change management framework for mining. Organisational change management is more of a top-down structured approach as viewed from the manager's perspective. It considers the activities and tools undertaken by the project team or change management resources to enable individual employees to successfully make the change. All change projects, particularly larger ones, should have some form of organisational change management framework to identify and support roles, and guide activities. Traditional organisational change activities such as communication and training are no longer sufficient to guide change; there needs to be greater attention paid to supporting individuals through change (Prosci, 2016a). Again, a structured organisational change management framework is discussed below in a change management framework for mining.

Why is change management needed?

Change management is needed more now than in years past because of a fundamental shift in value systems. The old organisational culture, which relied on top-down, command and control management styles, is disappearing. In its place, new employee value systems embrace empowerment, accountability and continuous improvement. Employees no longer respond to 'Jump' with 'How high'?, but rather 'Why'? (Hiatt, 2004). Thus, when a change is introduced into this evolving value system, it is natural for people to question the new initiative and indeed to resist.

Another justification for change management is illustrated with Prosci's Risk/Flight Model (Figure 2). In the absence of change management, after first hearing of a change that may impact an employee, that person may experience some anxiety. If left unmanaged, this could ultimately lead to the employee putting up resistance or worse, disengaging from the initiative and seeking an exit. Even worse would be an employee who disengages, but sticks around, posing a risk to the change.

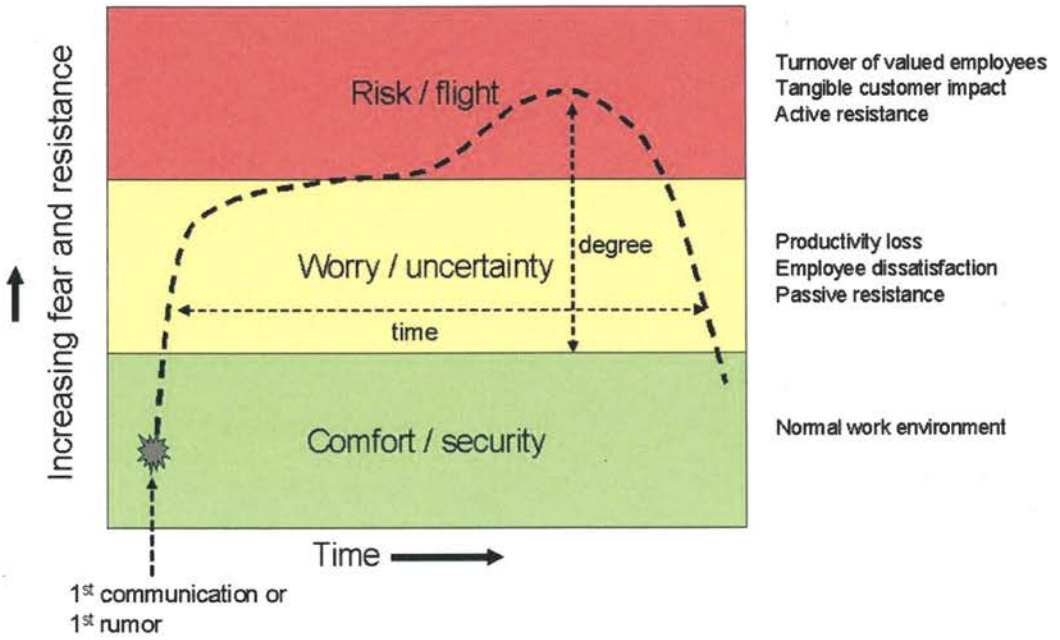

FIG 2 – Risk/flight model (Prosci, 2004b).

Prosci's research (Prosci, 2004a) has shown that when change is not managed:

- productivity declines as people become consumed with the change being introduced
- passive resistance festers
- active resistance emerges and sabotages the change
- valued employees leave the organisation, a very costly proposition in terms of the lost contribution and the cost to replace them
- people are left to wonder why the change is happening
- changes are not fully implemented
- changes are scrapped due to the lack of support throughout the organisation
- divides are created in the organisation between 'us' and 'them'
- the organisation builds a history of failed and painful changes.

The same research shows that when change is effectively managed:

- employees have a solid understanding of why change is happening
- employees engage in both the solution and the change
- training is used to build knowledge after employees have made the personal decision to support the change
- resistance is identified and dealt with early in the process
- communications are segmented and customised for different audiences, answering the questions that they care about
- momentum is built throughout different areas and levels within the organisation
- a coalition of support among senior leaders and managers creates momentum throughout the organisation
- probability of meeting project objectives is increased.

Finally, another rationale for change management is that it just makes good business sense. The three success factors for a change initiative are defined as:

1. the new system, process or organisational structure is installed and functioning
2. all the benefits expected are being realised
3. the benefits were realised in a timely manner.

Outright failure of a change project (success factor 1) might be rare, but certainly organisations not realising the full potential of a change (success factor 2), or taking longer than they should to

realise it (success factor 3), is much more common. Effectively, success factors 2 and 3 speak to return on investment (ROI). Change management is perhaps the best way to ensure that a project overcomes any obstacles, particularly employee resistance, to achieve or exceed expected ROI on change initiatives. According to a McKinsey and Company article (LaClair and Rao, 2002), projects that effectively managed change realised well over 100 per cent of the ROI expected, while projects that did not effectively manage change saw ROI at less than 50 per cent of expected.

KEY PRINCIPLES OF CHANGE MANAGEMENT

Message senders

It is important during change management that communications are appropriate, timely and ongoing. This is usually ensured through a well thought-out communication plan that is part of an organisational change management framework; however, it is critically important to identify the proper message sender for each type of communication.

For instance, for messages concerning: why the change is necessary, the risks of not changing and how the change relates to corporate strategy; employees want to hear these from the senior leaders. Specifically, in a change project, this should be the executive sponsor – the person recognised as leading the business. Where a specific mine is implementing a change, this could be the mine general manager; however, if multiple mines are impacted, this would be the chief operating officer or even the chief executive officer.

For messages concerning how a change impacts the employee and their team, employees want to hear from their immediate supervisors. Most importantly, messages that answer 'What's in it for me?' (WIIFM) need to be delivered by supervisors. Managers are employees too and so they need to hear such messages from senior managers or the executive sponsor.

Put most simply, messages are said to be either business messages or personal messages. Senior leaders are best suited to deliver business messages, while an employee's supervisor is best to deliver personal messages.

Authority for change

The executive sponsor is not just a talking head. Per the PCT model, the sponsor plays a key role in ensuring (Prosci, 2016a):

- sufficient resources and funding for the project
- established priorities between competing initiatives
- consistent support of the project in every business division or group
- employees understanding of why the change is being made and how the change aligns with the vision for the organisation
- the proper channel for resistant managers to resolve their objections.

According to a recent Prosci survey (Prosci, 2016a), 650 organisations cited ineffective change sponsorship as the number one obstacle to change. It is not sufficient to have a sponsor in name only. The sponsor needs to have control over people and systems impacted by the change. The sponsor needs to provide visible and ongoing support. Where warranted, the sponsor needs to build coalitions of sponsorship with other leaders whose employees need to support the change even though they are only indirectly impacted. The sponsor should not abandon the project part way through, thinking they have done enough or to pursue other priorities. Lastly, the sponsor should manage resistance as it occurs, particularly among managers.

A corollary of ineffective change sponsorship being the number one obstacle to change is that executive sponsorship is the number one success factor for change. This is born out in the Prosci surveys.

Resistance

Resistance is to be expected in a change initiative. It should not be reacted to with surprise, but rather anticipated. One should know where it may arise and have action plans or responses in place to prevent resistance or manage it. Expect that not all individuals will transition through the change process uniformly. After all, change for an individual is not an event but rather a process. No one

experiences the process the same and thus change management efforts must gauge where employees are in the process to adequately guide them and to prevent resistance from arising. Finally, managers must be enabled to become effective leaders by teaching them to manage resistance effectively.

In fact, managers are quite critical in managing resistance. They need to be trained in how to coach employees through the change to manage or remove employee resistance; however, they themselves need to be coached through the change. If managers are not on board or do not have the ability to coach their employees, this is a major obstacle to change. In Prosci's latest study, 60 per cent of participants said their organisations did not adequately prepare managers to lead change (Prosci, 2016b).

Change type

Change can be classified as incremental or radical according to how it occurs (Orlikowski, 1993):

- *Incremental change* represents an extension of the status quo, that is, adjustments or refinements in current products, practices, relationships, skills and norms. Such changes represent 'minor improvements or simple adjustments in current technology' (Dewar and Dutton, 1986, p 1423).
- *Radical change* requires a shift to fundamentally different products, practices, relationships, skills and norms. It involves adopting a different paradigm, a step which typically disrupts the established pattern of understandings and interests.

Ackerman Anderson and Anderson (2001) classify change in organisations in three ways: developmental, transitional and transformational:

1. *Developmental change* considers general organisational improvement, generating skills and improving performance. This is incremental change. Adoption of mining software to speed up mine planning processes would be an example of developmental change.
2. *Transitional change* is concerned with transitioning the organisation from one state to another through a series of steps that progressively dismantle the existing processes and establish new ones. Reorganisations and adoption of new technology to significantly improve current processes (eg remote mine/equipment operation, autonomous equipment) may be considered transitional changes. This is more often radical change.
3. *Transformational change* recognises that the change is so radical that it is not possible to transition from the existing state. It requires the shifting of culture, behaviour and mindsets to be successful. The future state of such change is not always known. Examples of transformational changes in mining might include mine method changes (moving from open pit to underground), adoption of IPCC and/or introduction of preconcentration. Often these changes are driven by profound changes in a business's environment or marketplace; they are radical changes.

The type of change, incremental or radical, transitional or transformational, will guide the change management strategy and change management plans deployed during the change.

The right answer is not enough

Markus and Benjamin (1997) provide an interesting assessment of technology-enabled change with their magic bullet theory. They suggest that technology specialists make the software tools (guns) that organisations will use to improve the way work is done. These specialists do not need to worry about who is to use these guns and how they are to be aimed: 'After all, they have designed them to fire magic bullets and magic bullets always hit their targets'! Managers and others who acquire new technology also believe in the magic of these bullets, so neither the technology specialists nor managers inherently practice proper change management to ensure that the promises of technology-enabled change are fulfilled.

The magic bullet theory is analogous to 'the right answer is not enough'. The perfect technology or process, as rational as it may seem, even accompanied by sound project management during implementation, will still require due care and attention to change management (ie the PCT model). Change management creates buy-in and commitment, while mitigating resistance and ensuring compliance. It bridges the gap between a sound technical solution and achieved value (eg ROI).

A CHANGE MANAGEMENT FRAMEWORK FOR MINING

A structured approach

In Prosci survey studies, a structured approach to change management has remained the second or third contributor to project success, with nearly 80 per cent of study participants utilising a structured approach (Prosci, 2016c). Consequently, in support of the implementation of real-time fleet management systems, the author developed a change management framework tailored specifically to implementing technology-driven change for the mining sector (McCarthy, 2005).

The framework consists of both an organisational change management aspect and an individual change management aspect.

Organisational change management

There are several well-known change management models that deal with organisational change management (Benjamin and Levinson, 1993; Kotter, 1996; Ackerman Anderson and Anderson, 2001; Prosci, 2004a). They all have a similar look and feel and typically identify eight to ten steps split up by phases or stages. Most commonly, there are three phases: preparation, design and planning, and implementation (though the names may differ according to the model).

Preparation phase

In the preparation phase, the change itself and the organisation are both assessed to guide the selection of a change management strategy. A change management strategy should be flexible enough to consider the nature of the change, the business needs of the organisation, the organisational culture and the expected levels of resistance. Change management strategies cannot follow generic templates.

To tailor the change management strategies, one must conduct assessments of:

- *the change* – assess the change in terms of scope, number of impacted employees, type (incremental or radical), degree and time frame
- *the organisation* – assess the organisation in terms of its change culture, employee value structure, change capacity (number of concurrent changes), change history, leadership style and power distribution, and middle management disposition.

Based on these assessments, a risk profile for change projects can be generated (Figure 3). The quadrants of this graphic become the basis of customising change management plans (see design and planning phase).

As part of preparing for change it is helpful to develop a vision, one that employees can relate to. Kotter (2002) describes the difference between two approaches to change: 'see-feel-change' versus 'analyse-think-change'. These two approaches operate at the individual level of change. Kotter maintains that effective change rarely occurs with analyse-think-change. At most, it gets numbers people – the engineers, accountants and managers – interested in the change. It takes see-feel-change methods to actually motivate people to get out there and make things happen, and to change behaviour.

By example, during the implementation of a fleet management system, the executive sponsor/mine general manager shared in employee communications that he often looks out at the primary crusher truck dump and sees truck queues and at other times, no trucks at all: 'Wouldn't it be nice if the new truck dispatch system would make us more efficient?' Employees can relate to that image.

Organizational Attributes / Change Size	Change Resistant	Change Ready
Large Change	High Risk	Medium Risk
Small Change	Medium Risk	Low Risk

FIG 3 – Risk profile for change projects.

Design and planning phase

In the design and planning phase, the models require the generation of various plans dictated by the change management strategy to help guide the change management efforts. Developed plans include communications plans, sponsor roadmap, training plans, resistance management plans, etc. The specific actions provided in these plans must reflect the information gathered in the preparation phase to best deal with the unique requirements of the change. An example of customising sponsorship for developing a sponsor roadmap is provided in Table 1. The same four quadrants as introduced in Figure 3 are the basis for customisation. One selects the quadrant appropriate for the change and organisation and customises accordingly.

Implementation phase

In the implementation phase, the change is implemented, data is gathered, resistance is monitored, gaps are analysed, adjustments are made and successes are celebrated. Toward the close of the implementation phase, these models call for making the change 'stick' in the organisational culture. This can take some time and thus may be separated into its own phase.

From these observations, an organisational change management structure was established for the implementation of technological change in mining. This is presented in Table 2.

Change management team

An integral part of any change project is the change management team (CMT). They are the ones who are delegated the responsibility to ensure that change management principles are adhered to. They perform the following:

- guide the development of the change management strategy
- develop the change management plans
- facilitate the training and coaching of managers and supervisors
- coach and advise the executive sponsor
- monitor the change to detect signs of resistance or opportunities to celebrate success
- generally ensure that the organisational change management framework is followed.

TABLE 1

Customisation of executive sponsorship.

Change characteristics					
	Large	**Large, radical change to change resistant organisation**		**Large, radical change to change ready organisation**	
		Minimum level of sponsorship:	Executive	Minimum level of sponsorship:	Executive
		Frequency of communication:	High	Frequency of communication:	Moderate
		Level of sponsor training:	High	Level of sponsor training:	Moderate
		Change management team support:	Hands-on	Change management team support:	Hands-on
		Resistance management:	Decisive	Resistance management:	Coach
		Feedback processes:	Formal & proactive	Feedback processes:	Formal
		Adherence to sponsor checklist:	Strict	Adherence to sponsor checklist:	Strict
	Small	**Small, incremental change to change resistant organisation**		**Small, incremental change to change ready organisation**	
		Minimum level of sponsorship:	Mid-manager	Minimum level of sponsorship:	Mid-manager
		Frequency of communication:	Moderate	Frequency of communication:	Low
		Level of sponsor training:	Moderate	Level of sponsor training:	Low to none
		Change management team support:	Guidance	Change management team support:	Job aides
		Resistance management:	Coach	Resistance management:	Minimal
		Feedback processes:	Informal	Feedback processes:	Informal
		Adherence to sponsor checklist:	Select items	Adherence to sponsor checklist:	Loose
		Resistant		**Ready**	
		Organisational attributes			

TABLE 2

An organisational change management framework for mining technology change.

Phase	Activities
1. Preparing for change	• understand the business reasons for the change; establish a sense of urgency • develop a vision for the changed state • assess the organisation's current state and ability to change • assess the magnitude of the change • select and prepare a change management team • prepare sponsor

2. Planning for change	• prepare the following change management plans:
	  • communications plan
	  • sponsor road map
	  • resistance management plan
	  • coaching plan
	  • training plan

3. Implementing change	• implement change • measure progress • identify gaps • resolve issues and adjust plans • manage resistance and recognise show stoppers
4. Reinforce and transition	• gather feedback on change success (or failure) • audit compliance; identify root causes of non-compliance • identify and implement corrective actions • generate and celebrate short-term wins • integrate change into culture

The CMT is trained in the discipline of change management. They can be appointed and trained for the purposes of a specific project or in a mature change-capable organisation, they may be employed as full-time specialists. Where the CMT includes change management specialists, it is still important to include domain experts on the CMT; these may be managers, supervisors or key front line staff.

There is some thinking that one needs a change agent or change champion to have a successful change project. For instance, the following was stated in relation to a mining change project (Jordaan and Hendricks, 2009):

> *... this solution was presented to a multidisciplinary team of technical experts. The proposal was found to be technically sound, as the technology proposed is mature and proven, however the decision was made to delay the project. This decision was based on the excessive risk of project failure or ability to realise the full potential benefit of the technology as a result of the skills shortages and lack of a mine site champion.*

However, while advantageous, a champion should not be seen as an imperative. *The whole success of a change, particularly a mining technology implementation, should not be dependent on one individual.* It is a team effort. If a project or technology is made dependent on an individual and that individual leaves, this becomes an unacceptable risk.

Individual change management

To help employees make the transition in a change project, it is important to understand the psychological process and drivers that they will experience. Prosci, based on its research, has developed a model that is both simple in how it can allow individuals make sense of transition and useful in how managers/supervisors can use it to coach individuals through change. It is the ADKAR model (awareness, desire, knowledge, ability and reinforcement), which is a five-step representation of how people individually progress through change:

1. *awareness* of the need to change

2. *desire* to participate and support the change
3. *knowledge* of how to change
4. *ability* to implement the change on a day-to-day basis
5. *reinforcement* to keep the change in place.

Individuals may vary in the time they spend in each step, but each step must be completed, and in the sequence presented for the change to succeed.

The implication of each individual needing to complete the steps and at their own pace is that an organisation cannot assume that their organisational change management strategies will draw all employees along at the same rate. Therefore, it is necessary to always 'measure' where employees are in the change progression to ensure that none are left behind.

Measuring progress through the ADKAR model is accomplished with employee coaching, using casual conversation and observation, a more structured interview process, or even written questionnaires. In assessing the results of an ADKAR evaluation, the first of any of the steps with a 'failing' score will require implementing actions to pass the step. One cannot address any one failed step unless all predecessor steps are passed.

IMPLEMENTING TECHNOLOGY IN MINING

Challenges with transparency

Challenges with transparency refers to issues that arise when there is visibility of the employee's actions or work (McCarthy, 2011). This relates to the movements of employees around the mine, attainment of planned work and forecasting of mine outputs. The premise is that per 'Big Brother' (George Orwell's *Nineteen Eighty-four*, 1949), employees do not like being watched while they are working. As a result, one can inherently expect resistance to arise.

There are three types of technologies deployed in mines that give rise to transparency issues:

1. *Fleet management systems* – capabilities include: automatically capturing equipment location and production data; tracking activities and equipment status; and optimising equipment assignments (computerised dispatching). Example products include: Modular Mining Systems (Dispatch®, Shiftboss™), Wenco (Wencomine™, Wencolite™), Caterpillar (MineStar™ Fleet), Hexagon (Jigsaw, SmartMine | UG) and MicroMine (PITRAM).
2. *Equipment monitoring systems* – capabilities include: data logging, equipment alarm event reporting and logging, real-time monitoring, trending and maintenance activity tracking. Example products include: Modular Mining Systems (MineCare®), Caterpillar (MineStar™ Health), Honeywell (Matrikon Mobile Equipment Monitor) and Wenco (Wenco Readyline).
3. *Production/reconciliation systems* – capabilities include: system integration, multiple measurement points, multiple data comparisons and reconciliation types (spatial, temporal, physical), notifications and reporting. Products include: Snowden (Reconcilor), GEOVIA (InSite™), Centric Mining Systems (Centric), Honeywell (Matrikon Mine to Port) and Triple Point (CXL Pit to Port®).

With fleet management systems, it is apparent where the transparency challenge lies. Employees are quite aware that with this technology their movements and activities are being monitored. This was an issue when this author first installed such technology in a coalmine in Canada. Fortunately this was anticipated and appropriate communications were provided; however, there were still isolated issues of complaints and even equipment damage. In addition to transparency issues, fleet management systems have the additional challenge of foremen or dispatchers having to give up dispatching control to a computer. The author has seen firsthand great reluctance to give up this control and thereby inhibiting one of the greatest benefits of such systems.

In the case of equipment monitoring systems, the technology enables others to see exactly how equipment is operated. For instance, in the case of haul trucks, it will show overspeeds, inappropriate application of braking or intentional rough driving. Operators may believe this capability will be used against them in a punitive way. While the potential for this exists, findings from such technology should be used as training opportunities.

Equipment monitoring systems also support predictive maintenance strategies. Such strategies represent a transformational change from the all-too-common breakdown maintenance strategy

that some companies are still mired in; however, it is recommended that equipment monitoring systems not be used as a catalyst for such transformational change, but rather as an enabler.

Lastly, for production/reconciliation systems, these enable the work of geologists, engineers and mine operations management to be verified. Such systems can show up variances in resource/reserve modelling, mine planning and mine plan compliance. While these should be considered continuous improvement opportunities, they have the potential to highlight shortcomings which those involved may not appreciate and may resist.

Automation

Automation is finding its way into the modern mine. Autonomous drills, LHDs and haul trucks for both underground and surface operations are being developed by Sandvik, Komatsu/Modular Mining, Caterpillar and Hitachi. The premise is simple: remove the operator from the equipment and realise benefits in:

- labour cost savings
- increased operating time per day
- precision/repeatability of processes
- maintenance cost savings
- tyre costs savings
- fuel savings.

However, removing operators and then having other employees working around driverless trucks, for example, presents a significant challenge in change management. Certainly mines that adopt autonomous haulage from the outset, such as FMG's Solomon Mine, have less of a challenge as there is no pre-existing workforce that needs to change. This does not mean that it will be easy, as no one in industry has experience with autonomous operations. Traditional ways will have to give way to this new reality.

Mines making the transition from person-operated haulage to autonomous haulage; however, certainly face a challenge in moving a workforce with current skills and experience to something quite different. While some jobs will be lost, other high-tech jobs will be created both in the operation and maintenance of autonomous systems.

Shifting paradigms

Something as imposing as changing the mining method, particularly moving from open pit to underground is a major transformational change that certainly would require change management. Equally challenging would be changes that essentially require the shifting of paradigms. A couple of examples of these are IPCC and preconcentration (sorting). In such instances you still have the same mining method but you must change the way you approach it. IPCC will be discussed in the next section, leaving preconcentration as the focus here.

Upon hearing the word 'sorting', most bring to mind the concept of particle sorting whereby conveyed material is scanned and individual particles are segregated at the discharge end of the conveyor. The presumption is that segregation is based on simple optical detection methods and that the process is low capacity. Consequently, one may be inclined to dismiss the potential of such technology, particularly in high throughput operations.

However, sorting is more than just particle sorting, it also includes bulk sorting where material can be detected and re-routed from conveyor belts in high volumes. As well, the mineral sensing technologies to enable segregation have evolved. In addition to optical methods, other surface sensing methods include XRF (X-ray fluorescence), XRL (X-ray luminescence), LIBS (laser-induced breakdown spectroscopy) and infrared (McCarthy, 2014). There are also penetrative sensing methods such as PGNAA (prompt gamma neutron activation analysis), PFTNA (pulsed fast and thermal neutron activation), radiometrics and XRT (X-ray transmission).

Sorting is used in any of:

- *preconcentration* – rejection of waste ahead of further processing
- *concentration* – segregation of final product
- *scavenging* – retention of mineralised material from a waste stream.

It is possible with sorting to combine these applications. For instance, using a penetrative sensing technology, bulk sorting can be used to preconcentrate conveyed material and then particle sorting, using either penetrative (XRT) or surface sensing could be used to scavenge the rejected stream. In this way, high volumes can be processed and the capacity limitation of particle sorting has minimal impact (McCarthy, 2014).

Exploring these concepts further, preconcentration is not just limited to sorting. There is also dense media separation and jigs – both gravity separation techniques. As well, size separation is being considered by SRK Consulting and others to take advantage of many ores where the deportment of mineralised material is to the finer size fractions. After applying appropriate blasting and crushing, ores may simply be screened to provide an enriched mill feed while rejecting below cut-off grade material to alternate processes or waste.

So presently, there may be a lack of understanding of the potential of sorting and preconcentration. While it may be harsh to suggest there is resistance to consider these technologies, certainly awareness needs to first be created so that miners understand the potential (the first 'A' in ADKAR).

Loss of flexibility

IPCC has for some time been promoted as a viable alternative to truck haulage in open pit mines. When one considers that rock is only half the mass that is moved in truck haulage (the rest being the truck itself), it is not difficult to understand that conveying material can be much less energy intensive, require less maintenance and supplies, and thus provide significant operating cost savings. However, miners generally have the belief that the capital cost is significant and that the loss of flexibility that comes with conveyors is insurmountable.

While it is true that IPCC can have a high price tag, when one considers that the equipment lasts for 20 years or more, the capital cost is actually not all that different from a traditional truck operation where two or three generations of truck fleets may be required over the life of the mine. In these instances, one might think it is a 'no brainer' to adopt IPCC. However, the shifting of paradigms and loss of flexibility factors come into play.

Ask a mine manager who has operated with haul trucks all his life to suddenly, with no additional personal benefit, implement IPCC at his mine. What is the expected response? It would be quite reasonable to assume that the manager would be resistant. Not only is it a paradigm shift, it is a journey into the unknown. And if he happens to inform himself, he may learn that IPCC has had mixed success. In fact, fully mobile IPCC (where a loading unit directly feeds a mobile crusher that discharges to a conveying system) has not been very successful at all.

Table 3 provides an overview of several known failures of IPCC systems. Failure here is noted as not meeting production expectations and in the worst case, system shutdown. While most of the failures are public knowledge, the specifics are not; thus anonymity is preserved. The majority of the failures are fully mobile systems (FM), with one semi-fixed system (SF). It is noted under technical (hard) issues, that the technology itself was not to blame. The crushers and conveyors performed as they should; however, they may not have been appropriate for the application. This points to poor mine planning and inappropriate selection of systems. According to Doug Turnbull of Sandvik:

> *To date, the industry has [used IPCC] without taking the baby steps to get there, good mine planning, mine planning to suit the equipment type, more good mine planning and lastly, good mine planning.* (Foley, 2012)

There is no doubt that mine planning is critical for IPCC – either fully mobile IPCC or semi-mobile IPCC (where trucks are still used to haul to crushers that are relocatable to keep within a few benches of the mining face). It is important that mine planning consider flexibility issues. While in the short term there may be constraints imposed by the timing of ore and waste release or blending requirements, good medium- and long-term mine planning can alleviate the need for short-term flexibility. This is more prevalent for fully mobile IPCC; semi-mobile IPCC has more flexibility at the mining face. Nonetheless, both need to consider how conveyors are situated to transport material out of the mine and how these are impacted by development of the mine.

Besides mine planning, Table 3 shows that there have been change management issues with these failed implementations as noted by the people (soft) issues.

TABLE 3
Sample in-pit crushing and conveying failures.

Site	Site 1	Site 2	Site 3	Site 4	Site 5
IPCC type (FM, SF)	FM	FM	FM	FM	SF
People (soft issues)					
Lack of visible and ongoing executive sponsorship	x	x	x		
Poor communication	x	x	x	x	x
Lack of training of operations/maintenance personnel	x	x	x	x	x
Lack of training of mine planning personnel	x	x	x	x	x
Employee/staff resistance	x	x	x	x	x
Managers/supervisors resistance	x	x			x
Cultural inertia/politics	x	x	x	x	x
Lack of resources to assist with change	x	x	x	x	x
Other:					
• IPCC was not considered primary production	x	x	x	x	x
• IPCC was last to be staffed up at start of shift				x	
• IPCC did not report to 'mining' department		x		x	x
Technical (hard issues)					
Design improvements needed					
Bad fit	x	x	x	x	x
Poor manufacturing.					

Note: FM – fully mobile system; SF – semi-fixed system.

All of the failures suffered from:

- poor communications
- lack of training (operations/maintenance/mine planning personnel)
- employee resistance
- cultural inertia (paradigm shift issues)
- lack of resources to assist with change issues.

Of note, most of the failures also had issues with executive sponsorship and manager resistance.

MINE MANAGEMENT IMPLICATIONS

Senior leaders and managers

It has been discussed that both senior leaders (executive sponsors) and managers play key roles in change management. Executive sponsors need to support project management and change management activities (the PCT model) and be the sender of key messages regarding how a technology change impacts or benefits the business. Managers on the other hand are critical in communications regarding the impact of the change on employees and in managing resistance.

However, these key stakeholders do not naturally know what needs to be done. Thus it is the responsibility of the CMT to work with them so they better understand their roles and activities. In reference to the recommended organisational change management structured approach (McCarthy, 2005), an executive sponsor road map should be developed to facilitate understanding of responsibilities and actions. With respect to managers and supervisors, the CMT should also develop a coaching plan that provides guidance on the following:

- group coaching:
  - ADKAR
  - communication
  - feedback

  - support of supervisors
- individual coaching – ADKAR
- proactive versus reactive actions
- feedback to the CMT.

As well, a communication plan should be maintained by the CMT to ensure appropriate and timely communications. Such a plan should consider:

- providing the business reasons for the change and the consequences of not changing
- including WIIFM answers early and often
- using face-to-face communication modes as much as possible
- repeating key messages several times
- creating opportunities for two-way communication.

In developing such plans and guidance, one needs to be aware of the capacity of managers and executives to absorb and execute. It may well become a change management exercise in itself to get mine management to fulfil the necessary roles to ensure successful change.

Technology specific considerations

We have herein considered a select number of mining technology implementations. Each involves different forms of change. A categorisation of the technologies by change type is provided below:

- *fleet management systems* – radical and transitional change
- *equipment monitoring systems* – radical and transitional change
- *autonomous systems* – radical and transitional change
- *production-tracking/reconciliation systems* – incremental and transitional change
- *sorting/preconcentration* – radical and transformational change
- *IPCC* – radical and transformational change.

It is noted that with the exception of production/reconciliation systems, all of these technologies represent radical changes, meaning that they need a change management strategy that is highly leveraged to the 'large' change end of the spectrum (Figure 3).

Regarding fleet management systems, some key lessons in this author's experience include:

- ensure that executive sponsorship exists and is visible and ongoing
- give representation to the employees most impacted by the change on the CMT – union executives work well in this regard
- ensure that ongoing communications are sent from the executive sponsor as well as managers and that the messages are appropriate for each
- ensure that WIIFM is part of those communications – often job preservation is involved as companies struggle to stay competitive
- identify potential resistance early both in terms of nature and source; actively engage with employees to ensure that business reasons and personal impacts are understood and no misinterpretation is allowed
- invest in training the employees and wherever possible use mine staff as trainers to complement the technology supplier.

For equipment monitoring systems, all of the above apply; and it is again important to use data that highlights poor operating practices to identify training opportunities instead of disciplinary opportunities. As well, if deploying such systems is part of a transformational change in maintenance strategies, this is a much greater exercise which should look beyond the technology to other enablers, such as business process engineering, for transforming the organisation.

With autonomous haulage, particularly when implementing into an operation with pre-existing person-operated truck fleets, there needs to be a focus on safety and training. Losing current employees certainly will have a temporary impact on those who remain and will require change management in its own right. However, for change to be successful going forward, employees need to be reassured of safety capabilities and receive training to both ensure their safety and acquire technical skills to operate in the new environment.

Implementing production-tracking/reconciliation systems is portrayed here as incremental change, but such systems tend to impact technical and managerial staff the most. These personnel are key to the functioning of the mine and so the consequence of failure or even resistance is severe. It is particularly important to do all the right things in change management, particularly communicating WIIFM answers. Identifying variances in one's work from reconciled outcomes should be portrayed as opportunities for improvement.

It is early days yet for sorting and preconcentration. Though these technologies have the potential to significantly change how mining is done; in many cases they have not passed the awareness stage of mine leadership's adoption process.

Finally, with IPCC, the following observations are made on how to approach its implementation (McCarthy, 2012):

- recognise that implementing IPCC is a multifaceted change:
  - a transformational change in how haulage is performed
  - a transformational change in how an operation is set up and run
  - a transitional change in how the operation is planned (mine planning)
- acknowledge that while IPCC may be an excellent technology solution with all kinds of promise, change management is needed – no magic bullets
- adopt an organisational change management framework
- consider WIIFM that highlights the acquisition of specialised (and marketable) IPCC skills
- mine planning... mine planning... mine planning (project design/management).

CONCLUSIONS

Mining companies seek to implement a broad range of technologies into their operations with the expectation that these will help them survive in ever more difficult times; however, technology-driven change has been a challenge for all organisations, and mining companies are not exempt. It is imperative that these companies include change management considerations in technology implementation projects to ensure that they achieve the expected ROI on such investments.

It is equally important that mining companies adopt a structured approach to change management, adopting both individual change management and organisational change management elements. This will ensure that management has a framework to follow that enables individual employees to make the transition to using new technologies.

In this, it is imperative that senior leaders and managers understand the importance they play in the change process, and that they are trained and guided in adopting change management principles. Successful technological change cannot happen without the visible and ongoing leadership of executive sponsors or the consistent coaching by managers to address potential resistance.

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