



INTEROPERABILITY

ALIGNMENT

Mining companies
working to align on principles,
needs and commitment

INTEROPERABILITY

Interoperability is the ability of two or more systems, components, or processes to exchange contextualized information so that they can act on this information to achieve business and operational outcomes.

EXECUTIVE SUMMARY

Interoperability is a requirement for the mining industry to benefit from advanced digital technologies that enable more productive, safe and cost-effective mines. It has, however, been very difficult to achieve due to a lack of alignment throughout the industry.

The Global Mining Guidelines Group (GMG) has established a strategy to coordinate an industry vision and collaborative drive for interoperability as part of the Interoperability and Functional Safety Acceleration Strategy (IFSAS). This process begins with mining company alignment.

A clear, unified voice from mining companies will provide the input Mining, Equipment, Technology and Services (METS) companies and industry organizations require to adapt and develop new tools and processes effectively.

This report captures the consensus among 17 mining companies gathered through in-depth interviews and workshops. The content used in these interviews and workshops is from the draft GMG Interoperability Definitions and Roadmap Guideline, the result of many workshops held around the world over the past two years with 120 participating companies.

What is alignment? All stakeholders moving in the same direction to approach a common challenge based on shared understanding of it.

There was alignment on the following six guiding principles:

- **Industry priority and importance:** Industry alignment on priorities and their level of importance is critical to the success of widespread, sustainable interoperability.
- **Data:** In order to be interoperable, a data interface needs to be self-describing and conform to published open standards.
- **Control:** Interoperability is a key enabler in the optimal operation and integration of control systems.
- **Cybersecurity:** Interoperable systems are vulnerable to cyber-attacks and the requirements for secure, effective systems need to be considered.
- **Safety:** Interoperability features, elements and processes must not compromise built-in safety features below the existing level of safety. They must follow established industry regulations, security requirements, and safety standards.
- **Governance/certification:** A robust and proactive governance framework will determine the effectiveness and sustainability of interoperability initiatives.

All mining companies engaged said that they are investing in automation, integration and digitalization initiatives, all of which require a high level of interoperability to be successful. Their priorities are to enable the sustainability, safety and productivity benefits associated with these initiatives and to achieve a higher level of transparency and openness between key stakeholders.

The mining company participants also outlined several ways they were willing to commit to interoperability. These include:

- Communicating aligned principles with suppliers
- Including interoperability in RFPs and contracts
- Approaching solution development collaboratively
- Providing test facilities
- Committing to education
- Offering ongoing feedback

Committing to interoperability is a collaborative effort. Moving forward, all stakeholder groups will need to agree on and follow similar steps.

This report is a working document that aims to serve as a starting point for achieving broader alignment among stakeholders. The consensus presented in this report and the feedback it generates will feed into the next steps to accelerate progress towards mine interoperability.

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GMG is a network of representatives from mining companies, OEMs, OTMs, research organizations and academics, consultants, regulators and industry associations around the world who collaborate to tackle challenges facing our industry.

We aim to accelerate the improvement of mining performance, safety and sustainability by creating guidelines addressing common industry challenges, expanding the industry's knowledge base, and hosting and supporting events that bring mining stakeholders together along with external industries to address challenges, successes and innovation.

See www.GMGgroup.org for more information.

Do you have feedback?

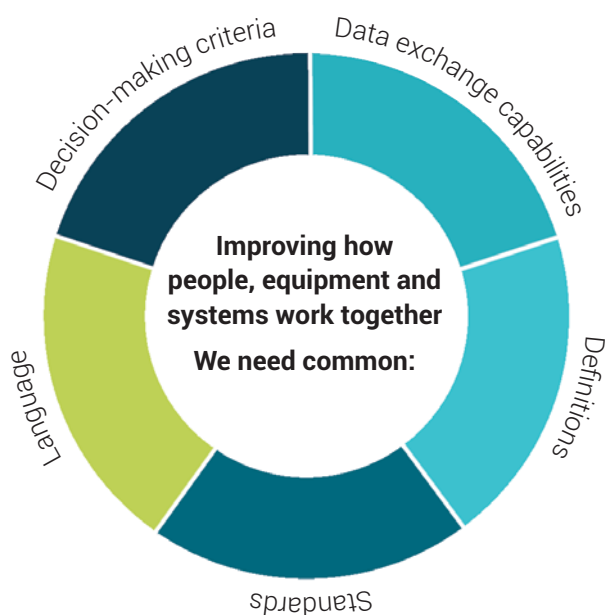
Contact Heather Ednie
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STRATEGIC CONTEXT

This report is part of a broader process for coordinating an industry vision and direction for interoperability through the GMG Interoperability and Functional Safety Acceleration Strategy (IFSAS). It captures the consensus among 17 mining companies gathered through interviews and workshops.

This report is a working document intended to drive further feedback and engagement from other mining companies and to engage the broader industry and will be updated as needed. The content and the further input it generates will feed into the next steps outlined on Page 23.

We are actively seeking feedback, input and participation. Please contact Heather Ednie, hednie@gmggroup.org



What is IFSAS?

In early 2019, GMG launched the Interoperability and Functional Safety Acceleration Strategy (IFSAS) with funding from BHP and Rio Tinto. The aim is to foster collaboration and accelerate progress on interoperability and functional safety for autonomous systems.

Functional safety and interoperability are intimately linked, as interoperability is required to enable greater levels of functional safety.

IFSAS OBJECTIVES

01

Build an industry vision and direction for interoperability and functional safety through mining company leadership

02

Work with, support and leverage other organizations, both inside and outside mining

03

Develop guidelines and tools

04

Coordinate communications and industry engagement – interoperability cannot be solved in a vacuum

INTEROPERABILITY ALIGNMENT: WHY WE NEED IT

Interoperability is important. Consensus is important. When companies are aligned, an industry can forge ahead safely and efficiently.

The future of mining is digital and requires interoperability to be realized. Advanced digital technologies are enhancing – and in many cases revolutionizing – equipment, processes, planning and execution, enabling more productive, safe and cost-effective mines. The interoperability of mining equipment and systems is essential to maximize the capability and benefit of digital technologies that enable mining automation, integration and data analytics.

Interest in and commitment to these technologies and the benefits they bring to mining operations is increasing. For example, all 17 of the mining companies engaged reported investment in automation, integration and digitalization initiatives, which is a clear indicator of the pressing need for interoperability commitment.

The benefits of interoperability include:

Improves productivity and safety

Enables the use of advanced digital technologies like AI, data analytics and autonomous systems

Leads to better environmental outcomes

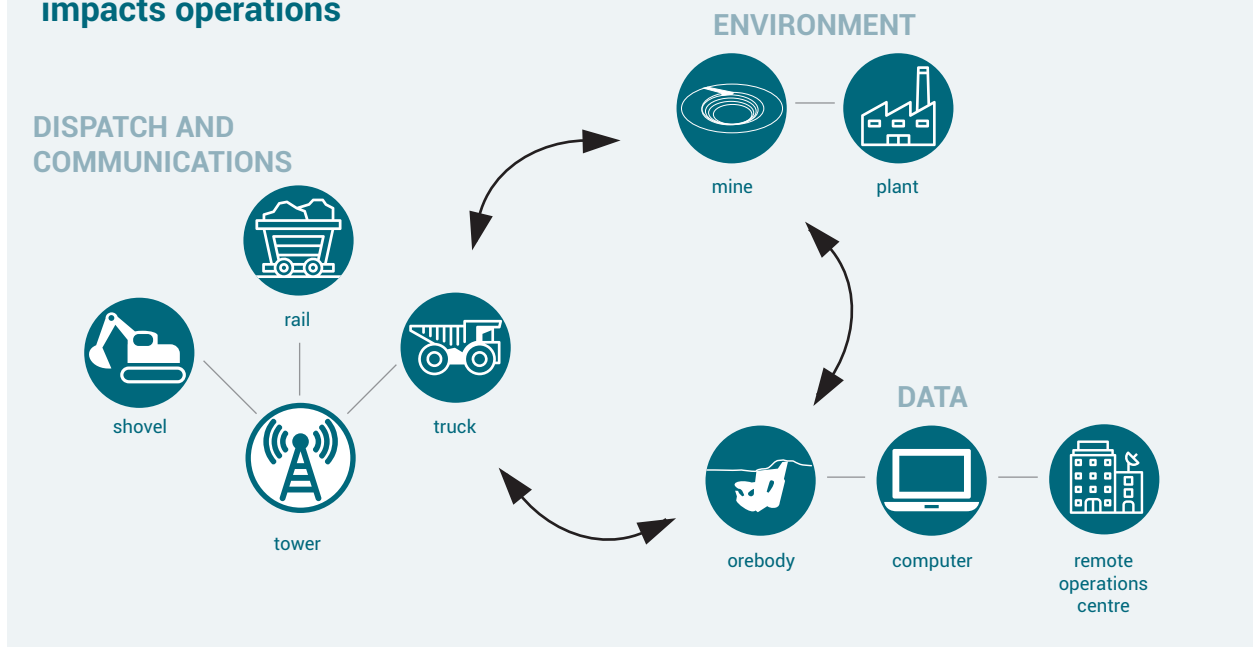
Lowers downtime and increases situational awareness

Brings in new suppliers with niche expertise

Lowers the cost of automation

Helps develop fully integrated supply chains

Examples of how interoperability impacts operations



There are many ongoing efforts to enable interoperability in mining that range from mining companies working directly with their suppliers for more interoperable solutions to external organizations developing tools, technology solutions and guidance. These initiatives, however, have not gained traction on a scale that will help the collective industry move forward.

Alignment on interoperability is essential. We need common definitions, standards, language, decision-making criteria and data exchange capabilities to improve how people, equipment and systems work together.

Creating a shared vision for the future and a coordinated, common approach to guide companies on this journey is essential if we are to overcome current challenges, which include:

- Lost productivity from maintaining and managing many separate systems;
- Difficulty acquiring, organizing and integrating data from diverse and incompatible sources;

- Risk of safety incidents due to conflicting safety systems in mixed-vendor fleets; and
- Restricted innovation and cost-effectiveness by being limited to a small number of suppliers.

It is clear that an issue as big as industry-wide interoperability requires global collaborative action. The greatest roadblocks are lack of clear industry-wide alignment and action on:

- A scope and framework for interoperability;
- Guiding interoperability principles;
- The priorities and initiatives for moving forward with interoperability; and
- Committing to interoperability.

The entire mining community needs to be aligned. Mining companies are most directly affected by the inefficiencies and safety concerns associated with poor interoperability. A clear, unified voice from mining companies will provide input mining equipment, technology and services (METS) companies and industry organizations require to adapt and develop new tools and processes effectively.

COMPANIES THAT PROVIDED INPUT

Agnico Eagle

Antofagasta Minerals

BHP

Boliden

CITIC Pacific Mining

Fortescue Metals
Group

Freeport-McMoRan

Glencore

Gold Fields

Ma'aden

Rio Tinto

Roy Hill

South32

Suncor

Synchrude

Teck

Vedanta

METHODOLOGY

This report presents the results of industry collaboration at two GMG-hosted workshops – the first took place on April 30, in Montreal, Canada, and the second on May 28, in Perth, Australia – and various interviews with mining companies conducted between March and May 2019.

Interviewees and workshop participants represented 17 mining operations over six continents. The companies involved also formed a representative cross section of the industry in terms of size and mining activities. The individuals were typically those with an information technology, engineering, operational or systems perspective.

These interviews and workshops covered:

- Defining interoperability
- Interoperability principles
- Interoperability priorities
- The vision for an interoperable future

The content used in the interviews and workshops came from the draft Interoperability Definitions and Roadmap Guideline. This draft content is the output of many workshops held around the world over the past two years with 120 participating companies representing a healthy cross section of stakeholder groups.

Interviewees and workshop participants were asked if they agreed or disagreed with the draft content provided and to identify and discuss any missing or incomplete information. They were also encouraged to share their thoughts based on their specific experiences.

The input was then consolidated and used to update and streamline the content. This report presents the results.

THE PRINCIPLES

The principles and their supporting tenets outlined in the following sections reflect agreement on guiding principles for mining interoperability.

These are essential for understanding:

what interoperability means in a mining context

fundamental implications, constraints, consequences, and dependencies of interoperability

rules and requirements for interoperability

Agreement on this information provides the industry with a tangible foundation for moving forward with interoperability. The global mining community can use these principles as guidance for developing, validating and applying beneficial industry-wide solutions.

INDUSTRY PRIORITY AND IMPORTANCE

Industry alignment on initiatives and priorities and their level of importance is critical to the success of widespread, sustainable interoperability.


Tenets

Digital technologies and processes contributing to improvements in safety, productivity, and profitability across the mining value chain are evolving and becoming increasingly interconnected. Interoperability is essential for taking full advantage of these technologies because the mining value chain must be effectively integrated to operate productively, safely, and profitably.

Interoperability drives improved integrated mining performance based on the belief – enabled by systems thinking – that cooperative cyber-physical systems will deliver greater capability and value than they can independently.

Interoperability will not stifle innovation. Instead, it will provide the framework upon which mining innovation can be built.

Interoperability models are dynamic and will evolve with changing and maturing technologies and business models.



"We are moving to operate all mines from cities, which needs common platforms and interconnected systems. Interoperability needs to be defined to enable this."

Why is this important?

Interoperability is a priority for the mining industry, driven by several key trends.


First, there is a ubiquitous move towards the digitalization and integration of business processes and operations in the quest for greater transparency and efficiency across the mine value chain. Optimization initiatives require the unhindered flow of data throughout a business and this can only be achieved if the systems linking each element are able to communicate effectively.

Second is the investigation and deployment of autonomous technologies. All 17 of the companies involved with IFSAS interviews and workshops are looking into, or currently deploying, some form of autonomous technology. These projects range in scale from autonomous haulage systems down to drones, but all have one thing in common: the ability to remove people from potentially dangerous or taxing environments.

Automation also feeds directly into the third trend, which is the use of remote control and remote operations asset management.

Every one of these initiatives requires interoperability in order to deliver its full potential. Without it, the effectiveness of implementing digital technologies is curtailed and data will remain siloed.

Having an aligned industry will enable dialogue, collaboration and progress towards realizing a sustainable interoperable approach to the development of systems and processes.



74% of global businesses state they have a digital strategy yet only **15%** believe they have the necessary capability and skill to execute the strategy.

The State of Digital Business Report, 2014 - Forrester

DATA

In order to be interoperable, a data interface needs to be self-describing and conform to published open standards.

Tenets

Mining equipment, systems, and processes that incorporate digital technologies should provide interfaces that:

- Facilitate information exchange between software;
- Enable interoperability;
- Are supplier neutral;
- Are independent of data ownership;
- Conform to published open standards for principles, architectures, platforms, semantics, message formats, and processes; and
- These interfaces should be well described or self-descriptive.

Interoperability requires that non-IP data be available for the owner/operator to use either in real time or in batch. It does not require that all data are freely and publicly available. Access to any data must consider privacy, proper authorization, and business rules.

Developing common data definitions needs to be an integral part of any interoperability initiative. Common terminology, semantics, and data definitions and a taxonomy for business processes, functions, and key data items are necessary to support interoperability.

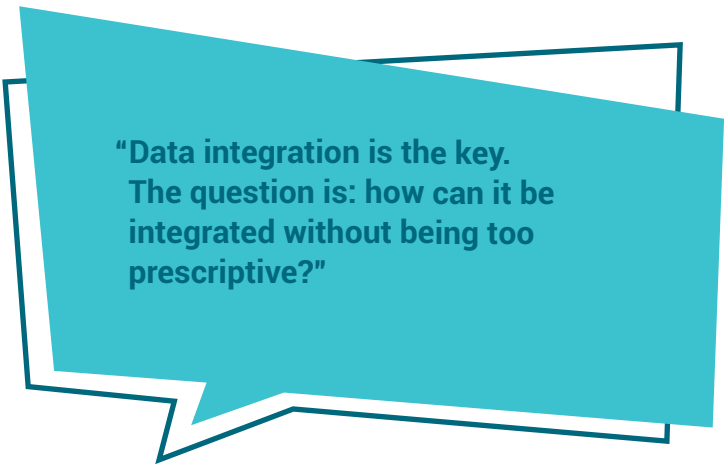
Why is this important?

The design principles outlined above underpin the development of any interoperable interface or application programming interface (API). In essence, they describe *how* systems should interoperate.

IFSAS stakeholders felt that further language could be added to describe the types of data required to make events, actions, state changes and conditions reached communicable and to rule out the possibility for misinterpretation. In this respect, there are a number of standards already in place that could be leveraged to help define common terminology, semantics and ontologies.

New standards will also be required, and the way in which they are written and developed will determine the balance between standardization and innovation within the industry; if standard requirements are too constrained or prescriptive then they risk dampening innovation, and if they are too loose, they risk being ineffective.

The answer of course will be collaboration. Mining companies, METS vendors and regulators will need to work closely with each other and, potentially, with stakeholders from other sectors to ensure a satisfactory outcome.



**“Data integration is the key.
The question is: how can it be
integrated without being too
prescriptive?”**

EXAMPLE

The goal of the GMG Open Mining Format (OMF) is to provide a self-describing interface to be able to exchange data between general mine planning software packages and scheduling applications and potentially traffic management systems for autonomous systems.

CONTROL

Interoperability is a key enabler in the optimal operation and integration of control systems.

Tenets

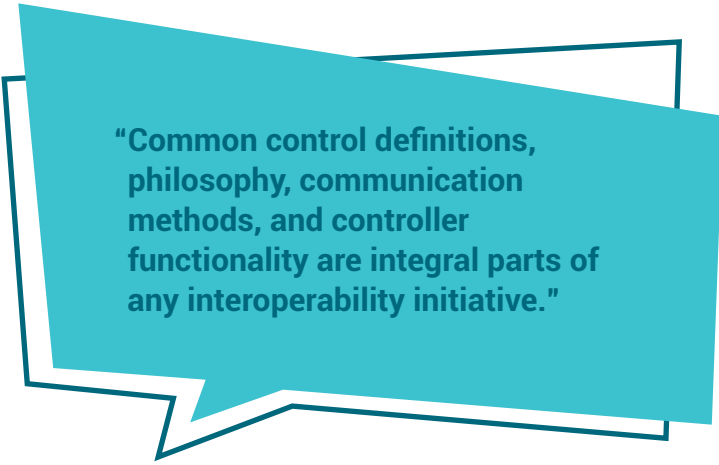
Interoperability requires a standardized approach to the interaction between controlled entities and/or control systems to optimize asset operations and complement the mining process. Common control definitions, control philosophy, communication methods, and controller functionality are integral parts of any interoperability initiative.

Interoperability must ensure that both similar and unique multi-vendor equipment and systems in a given mine ecosystem can be safely integrated, operated and maintained.

Why is this important?

Without interoperability, it is impossible to fully integrate or optimize systems performance within a mixed-vendor ecosystem, which is the norm at the vast majority of mining operations. Optimization initiatives are currently rife within the industry as miners seek to minimize ongoings and maximize their profit under tough operating conditions. These conditions are another reason why interoperability is so high on their agendas.

Control is also vital to safety; operators must be able to intervene in autonomous or remote operations and take control manually if the need arises. It is especially relevant to functional safety. For example, in a critical safety situation involving an autonomous truck, low interoperability between hardware and software from different vendors could hinder intervention and expose personnel to danger.



“Common control definitions, philosophy, communication methods, and controller functionality are integral parts of any interoperability initiative.”

As with the data principle, there are established standards that could be leveraged as a springboard for interoperability in control systems. For example, the International Organization for Standardization (ISO) is currently doing a great deal of work around autonomous equipment. It would also be wise to look outside of the mining industry; for example, the US military's Joint Strike Fighter definition could offer valuable learnings at a code level.

IFSAS stakeholders were generally happy with the tenets listed above but were clear that they must be comprehensible to a wide audience with different levels of understanding when it comes to fundamental control theory.

Governance, certification and compliance will also be key to achieving the vision outlined above which is why a separate principle was created to detail them.

EXAMPLE

One of the major areas of tension and frustration with autonomous equipment operation is the fact that all mine sites have a mixed fleet of equipment (across all types of equipment). Multiple systems working closely or in the same environment is a reality. The need for two or more systems to be interoperable at a control layer is important for a safe operation.

CYBERSECURITY

Interoperable systems are vulnerable to cyber-attacks and the requirements for secure, effective systems need to be considered.

Why is this important?

IFSAS stakeholders felt that cybersecurity and the way in which it applies to interoperability was important enough to warrant its addition as a standalone principle. It is also pervasive across the other principles.

The increasing use of information technology and operational technology, as well as a reliance on control systems for optimization purposes has increased the level of cyber risk that the mining industry is exposed to. Data is now a valuable commodity and if a system becomes compromised – depending on the scale of the incident – the implications can have a significant impact on a business' credibility and bottom line.

The integration of multiple systems from different vendors across operations can create points of weakness that could potentially be


Tenets

Interoperable systems, interfaces and processes should be resilient against security incidents by design and throughout their lifecycle.

Security requirements for control interfaces and data-only interfaces are different.

Security risks and requirements for interoperable interfaces need to be reviewed periodically to mitigate new risks.

Control and data interfaces should employ well-known standardized protocols that meet both functional and security requirements so that they can be interoperable.



“Security incidents will occur, and operational environments are at increasing risk of them.”

exploited by malicious actors. It is therefore important that resilience is built into interfaces at the design phase using concepts such as modularization, and consideration should be given to maintaining that resilience in the event of an attack. Being able to detect when a system has been compromised and having the capability to rectify the situation quickly, while limiting potential damages is extremely important.

SAFETY


Interoperability features, elements, and processes must not compromise built-in safety features below the existing level of safety. They must follow established industry regulations, security requirements, and safety standards.

Why is this important?

Mining exposes personnel to many hazards, making safety a pressing concern for the industry. Safety underpins all interoperability principles, and all interoperability initiatives should ensure overall safety is maintained at all times. Ensuring safety not only requires that regulations, requirements and standards are followed but also that everyone involved is aware of relevant standards and key processes and appropriately trained.

In particular, functional safety and interoperability are intimately linked. Alignment on interoperability will not only improve data transfer, communication and the productivity of technologies from various suppliers, it will also enable greater levels of functional safety for autonomous systems. While these systems have numerous safety benefits, they require many interdependent layers of protection to operate safely, and without seamless data exchange, they will not perform optimally.

Collaboration will be key to making standards and regulations both applicable over time and achievable.



“Interoperability features, elements, and processes must not compromise built in safety features.”

GOVERNANCE/ CERTIFICATION

A robust and proactive governance framework will determine the effectiveness and sustainability of interoperability initiatives.

"Regulators should be talking with each other, sharing and aligning on approaches."

Tenet

Interoperability requires transparent and inclusive governance and certification processes, an oversight organization, and common mining industry guidance that maintains the principles of interoperability. The oversight organization should comprise stakeholders across the entire value chain and learn from other industries. Stakeholders must be involved in defining data semantics and determining the context of the interoperability interfaces.

Why is this important?

The mining industry currently lacks an independent body to oversee interoperability efforts and provide high-level guidance.

During stakeholder discussions, the International Civil Aviation Organization (ICAO) was used as a desirable example from another industry. This organization was chosen because it provides governance at a sufficient level – over 200 countries are signed up to it – with the common goal to allow airplanes to land safely at their international airports. The organization provides a governance framework and an auditing function for the industry as well as a data sharing capability to

help facilitate that. When incidents do occur, key data is shared amongst members to help maximize learning opportunities and avoid repeats.

In the mining industry, regulations surrounding interoperability are currently fragmented from a maturity perspective; some jurisdictions have mature regulations and others less so. Having an organization similar to the ICAO for the resource sector would provide assistance with alignment on regulations and continuity between mining operations globally.

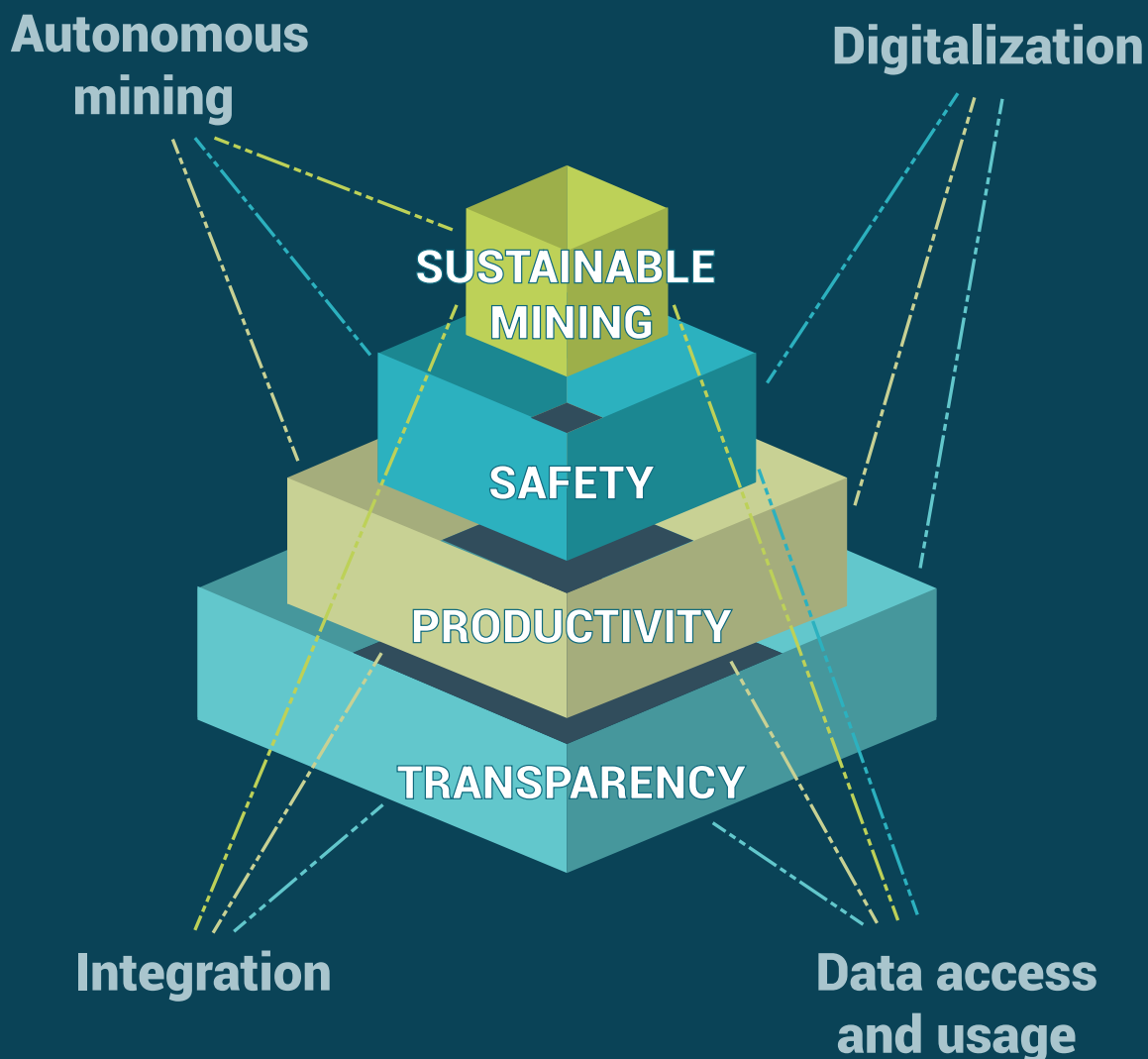
INDUSTRY PRIORITIES

Interoperability is required to enable innovation to address critical priorities for mining

The mining sector is united on key priorities for a viable future. Evolve or perish – increasing requirements are focusing attention: How can we improve the sustainability of operations? What will it take to make zero-harm the norm and get people out of the dirty, dangerous and dull jobs? How does productivity increase, even as orebodies are often more technically challenging? And how do we ensure an effective level of transparency across operations?

In response, mining companies around the globe are investing in autonomous mining, integration, digitalization and data. A unified vision of the future of mining is emerging, one shaped by disruptive technologies, new processes and operational models that leverage advances from other industries and address the requirements for the safe, sustainable, productive and innovative mine of the future.

Interoperability is a backbone requirement to enable innovation across these priority areas. Until interoperable solutions are available, mine operations are restricted in their ability to deploy new solutions. To make this great leap forward, we need to approach it differently – we need to work together and develop the solutions to drive the technology change we require.



COMMITMENT

The only way to drive change is to have the industry commit to it. This commitment will need to come from all stakeholders, globally, and will take several forms including:

Including interoperability requirements in RFPs and in contracts between mining companies and suppliers.

Mining companies communicating aligned principles to their suppliers so that they can develop tools and services in accordance with them. This communication can benefit both parties in several ways:

- Mining companies to be early adopters because they would know what to look for in solutions.
- Alignment with interoperability principles can be leveraged to enable more efficient mining company and supplier interactions. For example, onboarding processes for aligned solutions could be fast-tracked.
- Aligned principles can open up ways for suppliers to communicate to their customers that they are aligned with them.

Maintaining a high degree of trust and openness over time and offering feedback on initiatives and ideas that do and do not work so that that alignment can be sustained.

Treating solution development as a collaborative effort instead of treating each supplier relationship as separate. To achieve a collaborative atmosphere, developing a collaboration framework and setting rules of engagement so that all parties can work together on an integrated solution is necessary.

Providing facilities to test and prove the value of proposed solutions and to validate levels of interoperability.

Committing to education and talking about successes and failures so that the industry can learn from them.

Agreement and alignment on the principles outlined earlier in this document will underpin all forms of commitment. We welcome feedback and suggestions to ensure they best reflect an aligned industry.

The road to interoperability



An integrated, broad strategy is needed to enable the interoperability solutions for future mining. This is a call to action for the global industry to come together and collaborate towards a shared vision for the industry.

