GMG

INTEROPERABILITY DEFINITION AND GUIDING PRINCIPLES FOR THE MINING INDUSTRY

A GMG Report on the Outcomes of Industry Collaboration and Alignment

About the Global Mining Guidelines Group

The Global Mining Guidelines Group (GMG) is a network of representatives from mining companies, original equipment manufacturers (OEMs), original technology manufacturers (OTMs), research organizations and academics, consultants, regulators, and industry associations around the world who collaborate to tackle challenges facing our industry. GMG aims to accelerate the improvement of mining performance, safety, and sustainability by enabling the mining industry to collaborate and share expertise and lessons learned that result in the creation of guidelines and related documents that address common industry challenges.

Interested in participating or have feedback to share? GMG is an open platform, and everyone with interest and expertise in the subject matter covered can participate. Participants from GMG member companies have the opportunity to assume leadership roles. Please contact GMG at info@gmggroup.org for more information about participating or to provide feedback on this white paper.

GMG was formed out of the Surface Mining Association for Research and Technology (SMART) group as part of the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) and with the support of other Global Mineral Professionals Alliance (GMPA) members.

GMG is a legal entity of the Canadian Institute of Mining, Metallurgy and Petroleum.

ABOUT GMG REPORTS

Outcomes of outreach, industry research, and events can be presented in reports and can inform and be used as a reference for future work. They do not aim to provide industry guidance.

GMG reports are for informational purposes only and are not intended to be used as direct guidance. The use and application of this report is the responsibility of the user. The information provided in this document does not replace or alter standards or any other national, state, or local governmental statutes, laws, regulations, ordinances, or appropriate technical expertise and other requirements. While the report was developed and reviewed by participants across the mining industry, GMG cannot guarantee that it is accurate or complete, and it does not necessarily represent the views of all of the participating organizations. See the disclaimer at the end of the document for further detail.

Published 2021-08-27

EXECUTIVE SUMMARY

This report describes **a high-level foundation and reference** on interoperability in mining based on input that GMG has received from industry participants over four years. It aims to provide broad context on interoperability and its benefits in order to accommodate a global landscape with varied maturity and regulatory frameworks.

Many participants who provided input identified interoperability as an area of increasing importance. Interoperability can improve communication, enhance operational excellence, and improve the development and deployment of integrated mining systems. Some key needs that many participants identified include common definitions, standards, language, and data exchange capabilities. An open and collaborative environment that builds a consensus on achieving interoperability was identified as a key enabler.

Interoperability is **defined** as the ability of two or more systems, components, or processes to exchange information so they can act on this information to achieve business and operational outcomes. Interoperability has two fundamental constructs:

- The exchange of information, which can be bidirectional.
- The execution of actions initiated by the exchanged information.

Interoperability refers to many things and **applies widely across the mining value chain**. However, it does apply differently to different activities. Upstream and downstream operations were identified as priority areas that interoperability affects, but interoperability can also be a key enabler in understanding factors across several stages within the mining value chain. This report considers interoperability very broadly.

Key drivers for interoperability in the mining industry include:

- Interoperability can help mines improve the **performance of integrated mining** as optimization of operational equipment and systems is achieved across the mining value chain.
- Interoperability can help mines **achieve the cost benefits** of digitalization, automation, and integration.
- Interoperability can **drive innovation** by enabling new and existing systems to work together and by encouraging the industry to adopt innovative solutions and practices.

While this report and the industry engagement leading up to it focus on the benefits and drivers of interoperability in mining and does not cover the risks. Risks and alternatives should also be taken into consideration in decision-making around the choice to pursue interoperability.

The following **guiding principles** are intended to support future collaborative efforts:

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

2. Data and Interface: To be interoperable, data and data interfaces should be clearly described and open for use by the owners of the data.

3. Control: Interoperability benefits from an aligned approach to the interaction between controlled entities and/or control systems to optimize asset operations and complement the mining process.

4. Safety: Interoperability must not compromise on safety.

5. Cybersecurity: Interoperable systems can create additional cybersecurity challenges; therefore, change management and the requirements for secure and effective systems need to be considered.

6. Governance and Validation: A robust and proactive governance framework will determine and provide guidance on validating the effectiveness and sustainability of collaborative interoperability initiatives.

Another outcome of the industry engagement over the past four years is that, while there are many areas of agreement, interoperability remains a complex subject and there are varied views on its priority and benefits among industry stakeholders. The recently merged GMG Interoperability and Data Access and Usage working group will prioritize future efforts.

TABLE OF CONTENTS

1. INTRODUCTION

This report describes a high-level foundation and reference on the benefits of interoperability in mining based on input that GMG has received from industry participants over four years (see Section 2, Project History). It aims to provide broad context on interoperability in order to accommodate a global landscape with varied maturity and regulatory frameworks.

Intent

By sharing industry input on the drivers and context around interoperability in mining and identifying an aligned industry definition, and set of guiding principles, this report is intended to be a foundation and reference for more focused initiatives and is for informational purposes only. This report and the industry engagement leading up to it focuses on the benefits and drivers of interoperability in mining and does not cover the risks. Risks and alternatives should also be taken into consideration in decision-making around the choice to pursue interoperable solutions.

Because interoperability is a broad and complex topic and industry priorities and efforts around it are evolving, this report is intended to share the outcomes of a range of input and areas of agreement from GMG participants during cycles of engagement identified in Section 2. Some aspects of it may not represent an enduring agreement. The recently merged GMG Interoperability and Data Access and Usage working group will prioritize future efforts.

Interoperability Definition

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

- The exchange of information, which can be bidirectional.
- The execution of actions initiated by the exchanged information.

Industry Background

Many participants identified interoperability as an area of increasing importance. Interoperability can improve communication, enhance operational excellence, and improve the development and deployment of integrated mining systems. Advanced digital technologies are enhancing equipment, processes, planning, and execution in order to enable more productive, safe, and cost-effective mines. Many participants have identified interoperability between systems as an option for improving the capabilities and benefits of mining automation, digitalization, operational integration, and data analytics initiatives.

As more mining companies pursue digital transformation initiatives, many are looking for ways to achieve greater interoperability. A growing number of digital solutions are becoming available, but they often rely on proprietary data formats, interfaces, and platforms that make it difficult for companies to fully benefit from them. As these new solutions emerge, mining companies are looking to easily integrate them into existing infrastructure. Further, as more connected devices are being used to collect and share data, it is important that these devices communicate with each other. It is,

however, difficult for suppliers to address these changes without there being clarity and alignment on the needs, development approaches, priorities, and principles of their customers.

The Importance of an Open and Collaborative Approach

Many organizations are working independently on interoperability standards and guidelines but coordinating these initiatives is a challenge. The challenge is that interoperability is a broad and complex subject that affects all areas of operation. To illustrate, Figure 1 visualizes interoperability across the mining value chain: the arrows represent the bidirectional exchange of information that would require interoperable systems. Addressing interoperability requires not only a systems approach but also an environment wherein mining companies, original equipment manufacturers (OEMs), original technology manufacturers (OTMs), and other key stakeholders work together.

Some key needs that many participants identified include common definitions, standards, language and data exchange capabilities. An open and collaborative environment was identified as a key enabler. Examples of industry collaboration on interoperability include:

- Developing and using common guidelines, standards, and reference frameworks to define common needs and accelerate solutions. For example, OEMs and OTMs can respond better to the needs of the industry when there are clear standards and guidelines.
- Collaborating with and learning from other industries about how they address interoperability. For example, some industries have made significant progress in interoperability in communications and IT systems, such as Health Level 7, whose mission is to "provide standards that empower global health data interoperability", and the International Air Transport Association (IATA) One ID, for which the objective is to "achieve a truly interoperable system coordination between airports, airlines and governments."
- Leveraging testbeds and industry demonstrators to increase confidence in new technologies and help technology developers make improvements (e.g., the ERDi Testlab for energy and resources digital interoperability).
- Sharing case studies about successes and failures in order to identify what works.
- Establishing common goals and identifying common problems to anticipate, identify, and prepare for upcoming regulatory challenges.

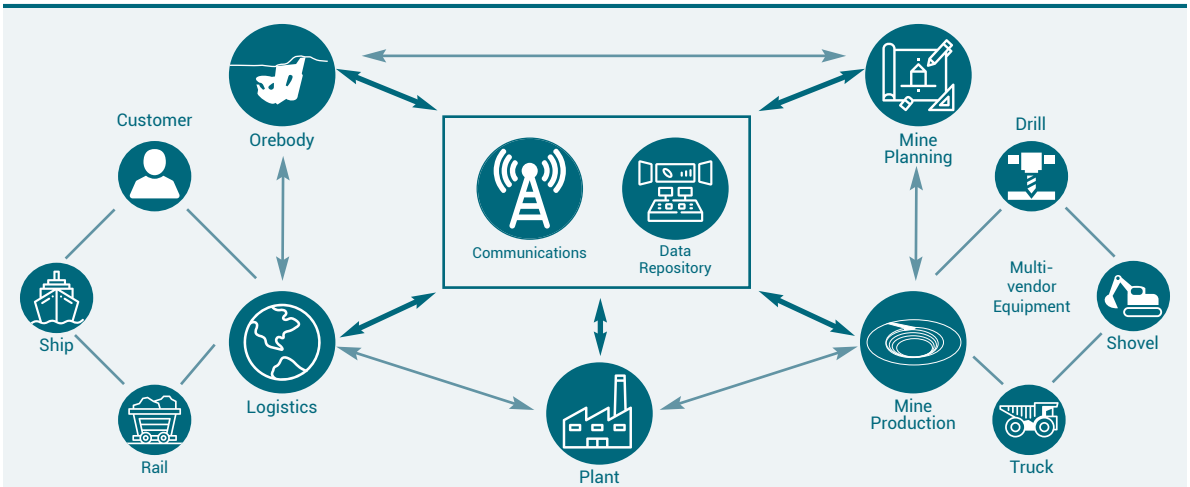

Figure 1. Examples of How Interoperability Affects Operations

2. PROJECT HISTORY

This report is the cumulative result of GMG industry engagement and alignment activities on interoperability for several years. This history is summarized in Figure 2 and described in greater detail in this section.

The project was initially launched under the GMG Interoperability Working Group to gain a consensus understanding of what interoperability is and its impact in the global mining industry. The guideline took a "mile wide, inch deep" approach to identify drivers, common definitions, industry principles, scope and future state, current and ongoing initiatives, a shared vision for the future, and a high-level roadmap. GMG held many guideline development workshops in Australia, Canada, Chile, Peru, South Africa, and the United States between 2017 and 2018 with participation from over 120 companies that represented a healthy cross-section of the international industry. These outcomes were consolidated into an initial draft.

In 2019, the guideline went to the Working Group for review, where participants identified that the document provided a good capture of the workshop outcomes and industry input, but it was not necessarily the right format for an industry guideline. In follow-up discussions, the principles were identified as core content and the project group decided to revise and reduce the content to focus on the drivers, definition, principles, context around industry priorities, and roadmap.

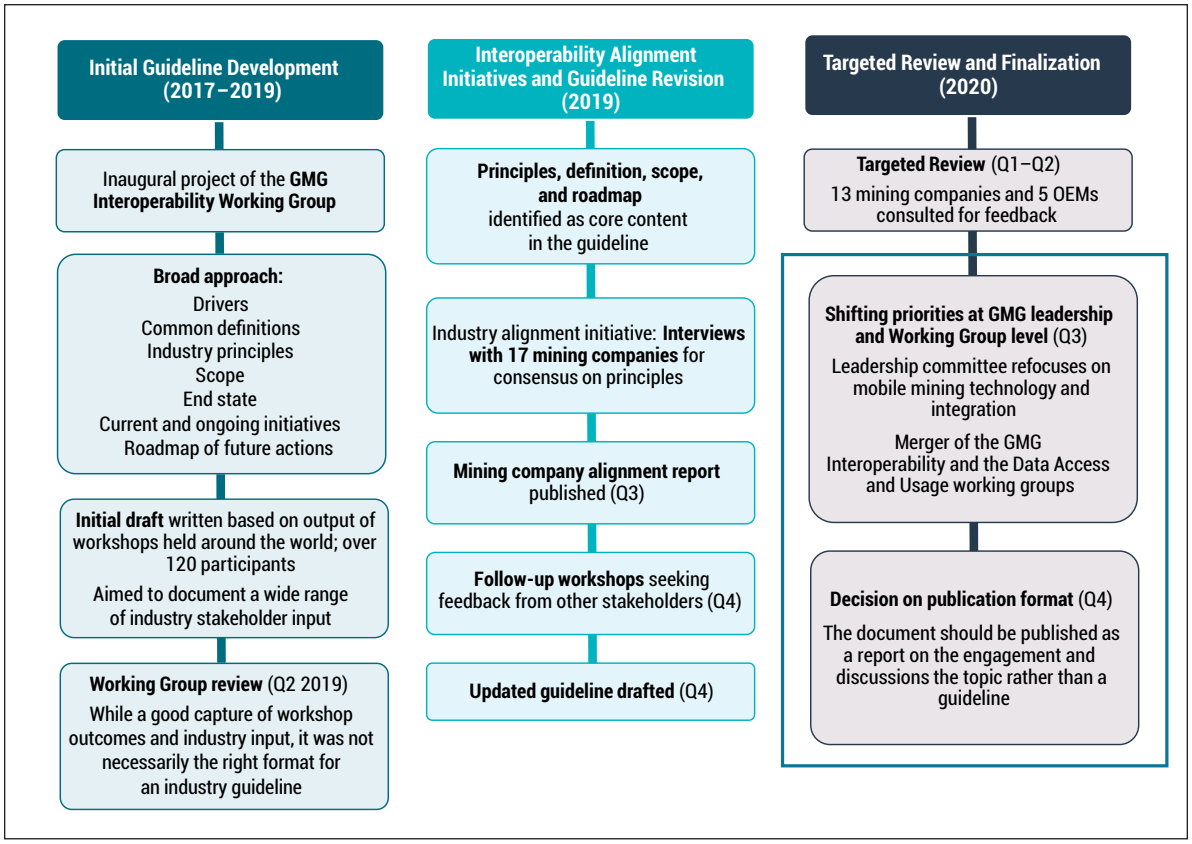

Figure 2. Summary of Project History

In response to an ongoing industry need for alignment on interoperability, GMG also ran a series of mining company–led interoperability alignment interviews and workshops later in 2019 where participants from 17 mining companies were asked to provide further input on the principles from the guideline draft. The results of this effort were published as a report in August 2019. These discussions were followed by broader workshops that sought further input from other stakeholders, after which an updated draft guideline was finalized.

The updated version of the guideline was then circulated for a targeted review during the first half of 2020 among GMG mining company and OEM members to identify any issues before proceeding with publication. The reviewers generally found the document to be informative and useful, but many participants felt it was time to complete the document and focus on moving forward on specific topics.

At the same time, the priorities within GMG leadership were also shifting toward mobile mining technology integration as a focus for the future, acknowledging that the preceding alignment and industry engagement was a key factor in the decision to focus on this topic. The GMG Interoperability and Data Access and Usage working groups also merged, and they will prioritize future efforts on interoperability (see Section 6).

At the end of 2020, a finalization committee with participants from all stages of the process met and decided that this document should be formatted as a report, rather than a guideline, and capture industry input. The roadmap was kept as a reference for future work (see Appendix A).

3. SCOPE OF INTEROPERABILITY IN MINING

Interoperability applies widely across the mining value chain. However, it does apply differently to different activities. For example, an interoperable operator interface would be a high priority during mine production, while interoperable orebody data would be a high priority for long-range planning.

Overall, upstream and downstream operations were identified as key priority areas. Participants from workshops (2017–2018) identified mine engineering, mine production, processing and plant production, maintenance and services, project logistics, long-range planning, and mine production control as the most affected by interoperability, based on the operational model presented in Figure 3, which identifies the highest level (level 1) business functions included in the mining value chain.

Interoperability also affects several of the shared services functions. The supply chain was identified as the highest priority among these functions because of its direct link to the mining value chain.

Interoperability can also be a key enabler in understanding factors across several stages within the mining value chain. For example, tracking orebody knowledge across all stages, all the way to the customer, is a use case that would be affected by interoperability in the current market environment.

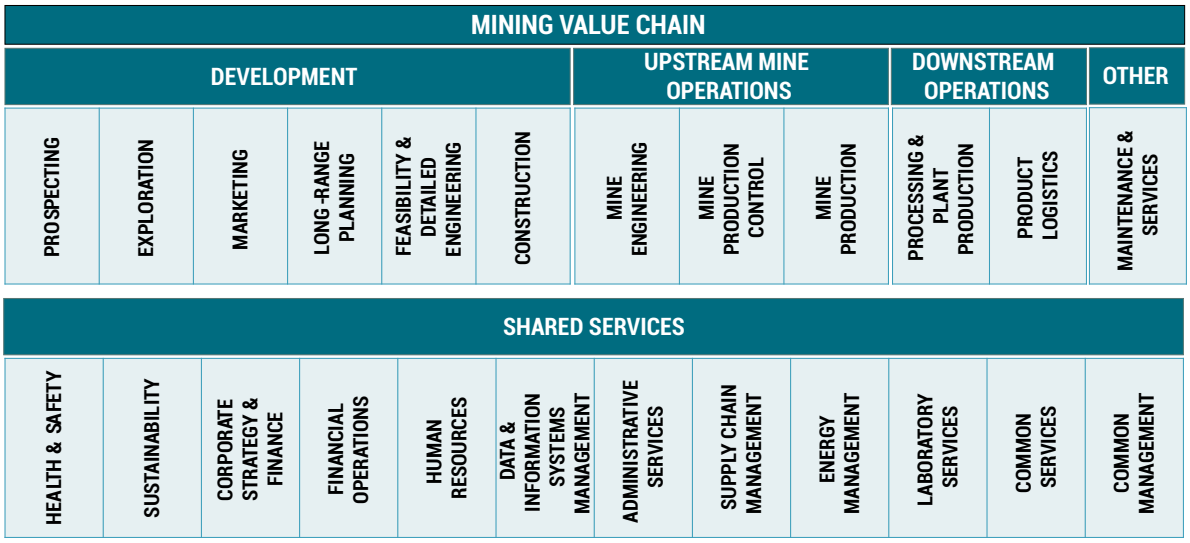

Figure 3. Mining Business Operational Model, Level 1 Functions (Courtesy of Tim Skinner, SMART Systems Group)

4. INTEROPERABILITY DRIVERS

This section outlines some of the key drivers for achieving broad, industry-wide interoperability as described in the industry background and as outlined by participants. Interoperability, however, is not without risks, and these drivers may not apply to all situations.

Integrated Mining Performance

Interoperability can improve the performance of integrated mining if it achieves the optimization of operational equipment and systems across the mining value chain.

Examples of how interoperability can improve integrated mining include:

- Improving situation awareness and, thereby, safety and productivity, by reducing the number of conflicting screens and operator interfaces.
- Reducing time and expenses wasted on efforts to develop, implement, and maintain independent proprietary, custom, or non-standard systems and methods.
- Helping to make sure that the integrated digital environment includes functional safety and duty of care as part of the design criteria.
- Increasing data visibility and consistency and enabling data-driven decision-making and collaboration between departments in order to eliminate redundant work.
- Enabling standardized processes, protocols, and industry data definitions across mining companies and operations.

Cost Reduction

As mining companies seek to improve profitability in the face of increasing costs and declining grades, there is an urgent demand for digitalization, automation, and integration. Many participants have identified interoperability as an option that can help to achieve the cost benefits these technologies bring. For example:

- Standardized testing and validation frameworks can allow for lower-cost development and the more efficient delivery of applications systems and technology infrastructure.
- Mining employs long-term assets, and interoperable solutions can sometimes offer opportunities to introduce new technology in multiple stages throughout the life of the asset.

Innovation

As the industry embraces digital and automation technologies and relies more heavily on them, interoperability can drive innovation. Introducing innovative solutions is often a staged process where new and old systems need to work together.

Beyond enabling the industry to adopt innovative digital solutions, some participants identified that interoperability can also enable more choice.

5. GUIDING PRINCIPLES

The principles and supporting tenets outlined in this section were developed and reviewed by industry participants to provide some fundamental requirements for collaborative interoperability in the mining industry. These principles are broad and aspirational and are intended to be used only as a reference to support initiatives and industry collaboration where interoperability has been identified as a good choice given the complexities, responsibilities, and trade-offs of the situation. As the industry evolves, the priorities among these principles and their applicability may also evolve and vary depending on the situation.

Industry Priority and Importance

Principle

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

Tenets

- The mining value chain should be effectively integrated in order to increase productivity, safety, and profitability.
- Interoperability is based on the belief—enabled by systems thinking—that cooperative systems can deliver greater capability and value than systems working independently.
- Reliable interoperability can enable innovation by providing a framework on which it can be built.
- Interoperability models are dynamic and able to adapt to changing and maturing technologies and business models.

Data and Interface

Principle

To be interoperable, data and data interfaces should be clearly described and open for use by the owners of the data.

Tenets

- Mining equipment and systems that incorporate digital technologies should provide interfaces that:
  - Facilitate information exchange between software programs
  - Enable interoperability
  - Are supplier neutral
  - Are independent of data ownership
  - Conform to published open standards for principles, architectures, platforms, semantics, message formats, and processes
- Interoperability requires that non–intellectual property (IP) data be available to use. It does not, however, require that all data be freely and publicly available. Access to any data must consider privacy, proper authorization, and business rules.
- Interoperability should be considered in mutually agreed terms pertaining to IP-related data.
- Common terminology, semantics, interface protocols, and data definitions and clear descriptions of business processes, functions, and key data items are necessary to support interoperability.

Control

Principle

Interoperability benefits from an aligned approach to the interaction between controlled entities and/or control systems to optimize asset operations and complement the mining process.

Tenets

- The aligned approach would include the consideration of common control definitions, control hierarchy, communication methods, and controller functionality.
- Interoperability aspires to support the safe integration and operation of both similar and unique multi-vendor equipment and systems in a given mine ecosystem.

Safety

Principle

Interoperability must not compromise on safety.

Tenets

- Interoperability features need to follow established industry regulations, security requirements, and safety standards.
- Interoperability will require risk assessments specific to the chosen implementation and consider any practical limitations that may exist in the process of adapting older equipment to new systems, the verification of any modification or additions, and the potential transfer of designer responsibilities for the safety/function of the implementation.

Cybersecurity

Principle

Interoperable systems can create additional cybersecurity challenges; therefore, change management and the requirements for secure and effective systems need to be considered.

Tenets

- Interoperable systems, interfaces, and processes should be resilient against security incidents by design.

Governance and Validation

Principle

A robust and proactive governance framework will determine and provide guidance on validating the effectiveness and sustainability of collaborative interoperability initiatives.

Tenets

- Broad and collaborative interoperability initiatives require transparent and inclusive governance processes, an organization or coalition for oversight, and common mining industry guidance that maintains the principles of interoperability.
- Those providing oversight should comprise stakeholders from across the entire value chain and be led based on guidance from those in industry leadership positions. It should also learn from other industries.
- All relevant stakeholders should be involved in defining data semantics and determining the context of the interoperability interfaces.
- The governance and validation framework should provide global guidance with enough flexibility for companies to comply with diverse regulatory requirements.

6. RELATED, ONGOING, AND FUTURE WORK

Related References

The following outcomes also came out of the industry engagement and alignment initiatives outlined in Section 2:

Interoperability Landscape	This landscape aims to increase the industry's understanding of what different organizations are doing on interoperability. An initial iteration covers ongoing or completed interoperability initiatives, solutions, tools, and projects. This is a live database and the outreach, feedback, and information gathering process will be ongoing. Available on the GMG website **here**.
Interoperability Roadmap	This roadmap compiles steps identified by participants (2017-2018) that may be taken to enable industry-wide interoperability in industry alignment and collaboration, standardization and reference framework development, applications and infrastructure, demonstration, and education. See Appendix A.

Ongoing Work

Future work on this topic will be covered by the recently merged GMG Interoperability and Data Access and Usage Working Groups, which were merged in 2020 because they shared much of the same community and their topics overlapped in many ways. The new group can still have separate focus areas or sub-committees to deal with different types of topics, such as interoperability. More focused and specific roadmaps, definitions, and common language and terminology could potentially emerge from this group. Learn more about the group **here**. Ongoing and proposed under this working group includes the following:

Data Exchange for Mine Software	The Open Mining Format (OMF) is an open-source serialization format and API library meant to support data interchange across the entire mining community. The continued development of this project seeks to enable seamless data transfer between different mine software and eliminate the chance of costly data errors - before they happen. v1.0 supports basic structures and v2.0, which is releasing in 2021, supports block models. Learn more **here**.
Mobile Equipment Open Data	Open data from mobile equipment can enable mine operators to make data-driven decisions that maximize equipment safety, utilization, and performance and foster innovation and continuous improvement. A guideline was published in 2016. Read it **here**. A 2021 report identified providing a foundation through common language and key use cases as priorities for future work. Read it **here**
Mobile Mining Technology Integration	The purpose of this proposed project is to develop a visual, generic categorization map with high-level details about relevant surface-mining mobile technology product terminology and outline how each product relates to other products. This project aims to solve a lack of alignment regarding common language across a mine site.

APPENDIX A: ROADMAP

This roadmap was developed between 2017 and 2018 to identify what steps were identified to enable industry-wide interoperability, with some edits for clarity in 2019–2020. Many of the items, especially in Phase 1, are currently underway both within GMG and in other organizations such as the ISO. See the **Interoperability Landscape** for examples. The aim of this roadmap is to capture the results of the input and work on the roadmap project and to be used as a reference for possible future work and more specific roadmap work. It is not intended to be exhaustive.

	Industry alignment: engagement and collaboration	Standardization and reference framework development	Applications and infrastructure	Demonstration	Education
PHASE 1	• Industry alignment on value, principles, priorities, and commitment • Governance organization • Communications, industry engagement, and information sharing • Operators, OEMs, and OTMs collaborating on solutions • Understanding of landscape and where there are gaps • Understanding of business case • Alignment on different types of interoperability risk assessments • Defining measures for success • Collaboration with other industries	• Map of activities, processes, and information flows • Defined reference architecture • Safety standards • Standardized semantic and data model	• Open standards developed and leveraged to enable interoperable technology • Maturity model • Industry understanding of applying interoperability to mixed fleets that while protecting intellectual property • Initial standard APIs • Aligned infrastructure platforms • Cybersecurity applied to interoperable technology and infrastructure	• Demonstrated value through case studies, proofs of concept, and demonstrations • Focus on short-term achievements	• Training for relevant new skills requirements • Organizations working with industry associations and educational institutions
PHASE 2	• Interoperability applied broadly to improve production in high-priority areas and based on agreed principles • Interoperability applied broadly to make orebody development more viable	• Agreement on standards • Coordinated global standards, solutions, and guidelines applied across the value chain	• Interoperable software / technology add-ins available • Integrated upstream resource knowledge with real-time production	• Small-scale pilot demonstrations • International commodity-specific testing environment for interoperability	• Available resources with interoperability experience and skillsets • Post-secondary training offered on interoperability
PHASE 3	• Solid foundation for interoperability • Open interoperability forms the basis for the international industry • Sustained collaborative innovation	• Continuous improvement and standards development	• Fully integrated supply chains • Continuous improvement	• Demonstrated overall cost reduction through interoperability	• Universities supporting and expanding support for interoperability

DISCLAIMER

This publication contains general information only and does not replace or alter requirements of any national, state, or local governmental statutes, laws, regulations, ordinances, or appropriate technical expertise and other requirements. Although reasonable precautions have been taken to verify the information contained in this publication as of the date of publication, it is being distributed without warranty of any kind, either express or implied. This document has been prepared with the input of various Global Mining Guidelines Group (GMG) members and other participants from the industry, but the publications do not necessarily represent the views of GMG and the organizations involved in the preparation of this document. Use of GMG publications is entirely voluntary. The responsibility for the interpretation and use of this publication lies with the user (who should not assume that it is error-free or that it will be suitable for the user's purpose). GMG and the organizations involved in the preparation of this publication assume no responsibility whatsoever for errors or omissions in this publication or in other source materials that are referenced by this publication, and expressly disclaim the same. GMG expressly disclaims any responsibility related to determination or implementation of any management practice. In no event shall CIM or GMG (including its members, partners, staff, contributors, reviewers, or editors to this publication) be liable for damages or losses of any kind, however arising, from the use of or reliance on this document, or implementation of any plan, policy, guidance, or decision, or the like, based on this general guidance. CIM and GMG (including its members, partners, staff, contributors, reviewers, or editors to this publication) also disclaims any liability of any nature whatsoever, whether under equity, common law, tort, contract, estoppel, negligence, strict liability, or any other theory, for any direct, incidental, special, punitive, consequential, or indirect damages arising from or related to the use of or reliance on this document. CIM and GMG (including its members, partners, staff, contributors, reviewers, or editors to this publication) are not responsible for, and make no representation(s) about, the content or reliability of linked websites, and linking should not be taken as endorsement of any kind. We have no control over the availability of linked pages and accept no responsibility for them. The mention of specific entities, individuals, source materials, trade names, or commercial processes in this publication does not constitute endorsement by CIM and GMG (including its members, partners, staff, contributors, reviewers, or editors to this publication). In addition, the designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of CIM and GMG (including its members, partners, staff, contributors, reviewers, or editors to this publication) on the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of any frontiers or boundaries. This disclaimer should be construed in accordance with the laws of Canada.

GLOBAL MINING GUIDELINES GROUP

GMG

Innovation through Collaboration