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Smart mining and metals operations

Harmonize across the IT/OT nexus to unlock sustainable value

Introduction

From mitigating the effects of orebody uncertainty on production to balancing safety with profitability and sustainability, running mining and metals operations successfully can be a complex and nuanced business.

For the organizations tasked with meeting the world's increasing demand for minerals and metals while addressing fast-moving investor, regulatory and public expectations, there are complicated and, sometimes, difficult choices to be made. Optimizing the value of mature assets while driving future production through strategic operational improvements as well as greenfield investments is an ongoing priority for these organizations.

These forces have given rise to five key imperatives for operators to contemplate:

1. Designing and developing mining and metals operations to be 'smart' from day one
2. Driving safe and reliable operations at the lowest cost per ton
3. Delivering operational decarbonization and sustainability commitments
4. Enabling enterprise-level decision-making across the value chain
5. Attracting and retaining skilled talent by rethinking the nature of current and future work

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Realizing value from smart tools and technologies by enabling a harmonized IT/ OT delivery capability

To help maintain a competitive edge, many mining and metals providers are investing in operational capabilities that make their organizations, and specifically their operations, more resilient, agile and attractive through fluctuating economic conditions. For example, operating facilities as a single system at the value chain level through an Integrated Remote Operating Centre (IROC) or as a portfolio of integrated assets, rather than standalone operations, can enable new ways of working through smart, interconnected and digitally enabled capabilities.

This shift can require organizations to leverage data for insights in areas such as:

- Operational strategy, planning, and execution
- Optimizing cost and productivity
- Maintenance and reliability
- Expansion, rebuild and refurbishment programs
- Engineering, asset management and master data management (MDM), and
- Strategic workforce management

To achieve this, many operators are making sizable investments into integrated solutions that drive faster, more repeatable decisions across their operations through value chain optimization solutions (See case study on page 6). Meanwhile, others are taking a more focused approach to improve functional capabilities, such as autonomous fleet rollouts and enablement.

In most smart operations projects, information technology and operation technology (IT and OT) teams should come together to deliver the outcomes the business requires. Historically, these functions have been managed in silos. OT systems, like supervisory control and data acquisition (SCADA), programmable logic controller (PLC), and distributed control systems (DCS), control and monitor physical processes, while IT systems, like enterprise resource planning (ERP), enterprise asset management (EAM), and analytics platforms, handle planning, scheduling, finance and maintenance. This separation made sense when OT was isolated, deterministic and proprietary. But in today's digital era, the value lies in connecting these worlds to help unlock powerful insights—such as predicting asset failures, optimizing energy use, or improving throughput across a value chain.

It's also not uncommon for business units to attempt to get ahead of the curve by piloting digital solutions or initiating proof of concepts (POCs) individually. If approached in an unstructured manner, these initiatives may end up competing with similar use cases already being trialed elsewhere in the same organization (a clear waste of time and resources). Also, the solutions implemented may not be suitable for scaling across the asset, let alone the enterprise, which could limit its effectiveness and potential return on investment (ROI).

Taking a considered approach to connected, automated and integrated operations

While functions across mining and metals businesses are often siloed, the use of digital technologies may not be. An investment in a single digital upgrade can impact workers, business processes, and other technologies within a facility and, often, across the enterprise. For example, an investment in drone surveillance to inspect an overland conveyor system running from the pit to plant, rather than using on-site, manned crews, can have many implications.

Consider the following questions:

- Do manual inspections drive unit operating and maintenance costs in a significant way?
- Will eliminating manual inspections significantly improve the performance of the conveyors?
- Are digital and robotics technologies integrated with maintenance workflows to support employees in making effective decisions and taking the right actions concerning reactive and predictive maintenance?
- Does the organization have the core IT, data, network, and hardware systems to support the surveillance program and to keep it safe from a cybersecurity perspective?
- Is the organization equipped to consume, manage, and analyze the spatial data produced by the advanced robotics system?
- Do employees have the competency to operate these digitally enabled systems safely and effectively?
- Are there facility and/or enterprise processes, standards, and instructions in place to operate the system in a safe, sound, and compliant manner?

Whether the business objective is broad or targeted, achieving it will likely require process modifications and workforce considerations, as well as a foundation of computing, connectivity, data management and cybersecurity competencies.

The investments needed to build this foundation, and to scale the IT and the OT components required, as well as the overarching analytics that oversee it, will likely transcend the business units and functional silos. As a result, organizations need to think about these changes in a structured way to help ensure they deliver maximum value for their organizations.

Supporting the shift to smart operations

The convergence of IT and OT is an important theme for the mining and metals sector and different clients have different levels of maturity and requirements from these functions. The integration of these traditionally separate domains can, however, deliver enhanced operational efficiency, improved decision-making and increased competitiveness and help to ensure that convergence efforts or smart operation's projects are implemented in a cyber-safe way.

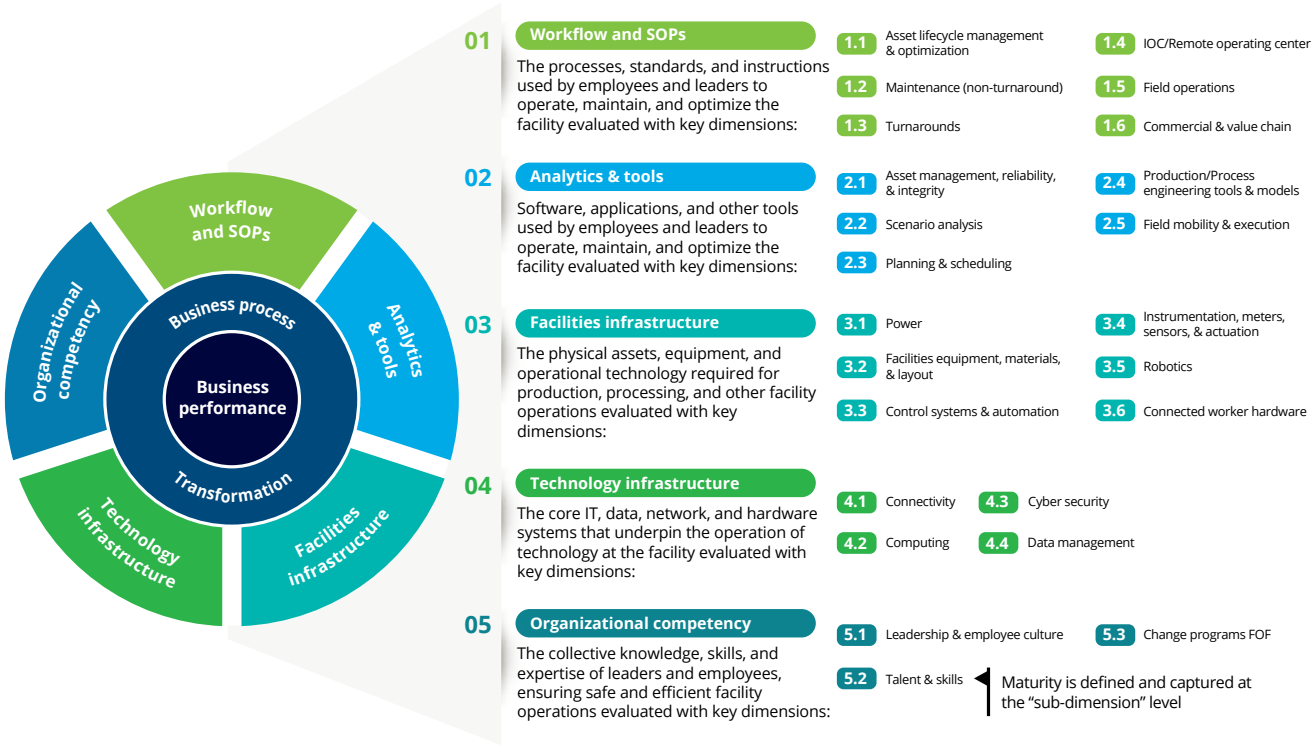
For instance, bringing IT and OT closer together could enable real-time data collection, contextualization, sharing and analytics both across the value chain from pit-to-port, as well as vertically from sensor to decision in either a function, at an operation, or in an IROC. This shift could increase organizational efficiency by reducing the effort that currently goes into weekly and monthly data collection and cleansing activities to enable operational reporting and improve the speed and accuracy of data-based decisions.

However, IT and OT convergence is about more than technology. It can also require transformation across both IT and OT organizations, as well as across the technology delivery chain, ranging from vision and strategy to deployment, security, operations and maintenance after go-live.

To support selected aspects of this transformation, Deloitte has developed the Facility of the Future (FoF) Framework (See figure 1). This is a standardized tool for assessing current-state technologies, workflows, and organizational maturity levels across businesses in the energy, resources and industrial sectors.

The framework can also expose current limitations and presents options for helping to address them. This helps business leaders understand trade-offs and key considerations when determining how, when and where to invest across the IT and OT landscape. The framework's structured approach means that the exercise is repeatable across portfolios of diverse assets. This enables robust investment strategies to emerge across the enterprise and makes the framework directly applicable for companies in the mining and metals industry.

Figure 1: Facility of the future assessment framework



Source: Deloitte Analysis

Defining the organization's next steps

For integrated organizations, it can be tempting to race ahead with transformational digital deployments. The compounding benefits of high-potential use cases, such as equipment failure prediction using artificial intelligence (AI), machine learning, advanced robotics inspections and surveillance, condition-based maintenance programs, and closed-loop equipment optimization (i.e., self-diagnostic and self-healing), can have great allure.

However, IT and OT convergence can often become a bottleneck and can raise many people, process and technology considerations that should be addressed systematically. This can enable leaders to make informed investment decisions that achieve outcomes, such as reduced operating costs, increased production efficiency and lower carbon intensity, through a coordinated approach where stakeholders are clear on their roles and responsibilities.

For companies looking to create smart operations, IT and OT convergence should be addressed, and the ROI is often dependent upon blending cutting-edge technologies with practical execution to help achieve sustainable outcomes. Here are five key considerations for mitigating risk through this process:

1. **Build a unified foundation**
   Start with a framework that brings together IT and OT. This means investing in interoperable systems – think industrial IoT platforms or middleware – that can talk to both legacy equipment and modern cloud platforms. Prioritize standardized protocols, such as the Open Platform Communications Unified Architecture (OPC UA), to enable longevity and help future-proof the setup. The goal is to create a single industrial data operations platform, enabling integrated and often real-time views of operations, from mining equipment performance to supply chain data, without difficult handoffs. The intention is not to replace old systems but making systems both old and new work well together in a fit-for-purpose solution architecture.

2. **Embed cybersecurity from the ground up**
   Security isn't an add-on; it's the bedrock of smart mining and metals operations. Mines of the future will likely be hyper-connected, apply a zero-trust architecture – verify everything, but assume nothing – across networks, devices, and users. Segment OT systems from IT where possible, use air-gapped backups for critical controls, and lean on AI-driven threat detection to catch anomalies fast. Regular stress-testing and compliance with standards like NIST 800-82 – a guide to OT cybersecurity from the National institute of standards and technology – can help to keep risks in check.

3. **Leverage data with purpose**
   Turn the flood of sensor and process data into a strategic asset and avoid cognitive and/or data overload of operational decision makers. Deploy edge computing to process time-sensitive information on-site, while funneling bigger data sets to the cloud where advanced analytics and AI-enabled modeling can be applied. Focus on use cases with clear wins, such as reducing energy wastage, minimizing downtime or boosting safety. The key is to avoid data overload: curate what matters and remove the unnecessary data.

4. **Empower the workforce**
   People can make or break this shift. Invest in training programs that bridge the IT and OT divide. Teach operators to use digital dashboards and train IT personnel in mining and metals processes and technologies. Digital twins or augmented reality tools can ease the transition, letting workers simulate scenarios or troubleshoot hands-on without risking their safety or production. Culture matters too. Champion early adopters, reward innovation, and consider hiring hybrid talents who understand both worlds.

5. **Plan for scalable, sustainable growth**
   Design smart operations with the long game in mind but start small. Pilot a smart system at one site, but architect it to scale across the organization's portfolio without duplicating efforts. Balance capital expenditures with phased rollouts to help keep costs manageable, and track ROI to justify each step.

The value of smart operations tools in strategic mine planning

To make strategic decisions for complex and integrated mining and metals assets, such as iron-ore operations, companies should test the impact of different scenarios and changes to their supply chains and evaluate the effects on systems throughput. For instance, key use cases for simulation and optimization software tools might include:

- **Developing asset maintenance plans:** Generate rail and fixed plant maintenance plans based on high-level requirements and planning rules.
- **Designing future mines:** Evaluate the impact of new mines on a portfolio and investigate strategies to ramp-up production.
- **Operational improvement initiatives:** Evaluate the impact of planned initiatives on expected supply chain throughput.
- **Pathway to the energy transition:** Evaluate the impact of using battery-powered vehicles across the operation.

The challenge

Deloitte Australia was recently engaged by a global mining company to develop a solution that could support decision making in these types of scenarios. Three workstreams were identified:

1. The technical workstream built an ingestion engine in Python and executed functions in the client's selected cloud platform: AZURE.
2. The modelling workstream built discrete simulation models of the value chain in Python and SimPy, using VS Code, AZURE DevOps and Git.
3. The ways of working workstream focused on developing the identity of the project through showcase delivery and a single source of truth for project collateral.

Outcomes and value delivered

The project delivered the following benefits:

- The client now has a self-service app that enables users to execute simulations without the need for subject matter specialists.
- Data ingestion is now available in near-real time. Previously, manual data ingestion was lengthy and tiresome.
- Maintenance schedules can be generated in less than 24 hours – a reduction of six weeks. This allows planners to utilize this time for optimization activities.
- The client's digital teams are trained in Python and SimPy, meaning they are ready for feature enhancements and bug remediation tasks.
- A single source of truth has been created for all integrated system model (ISM) documentation and training.

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