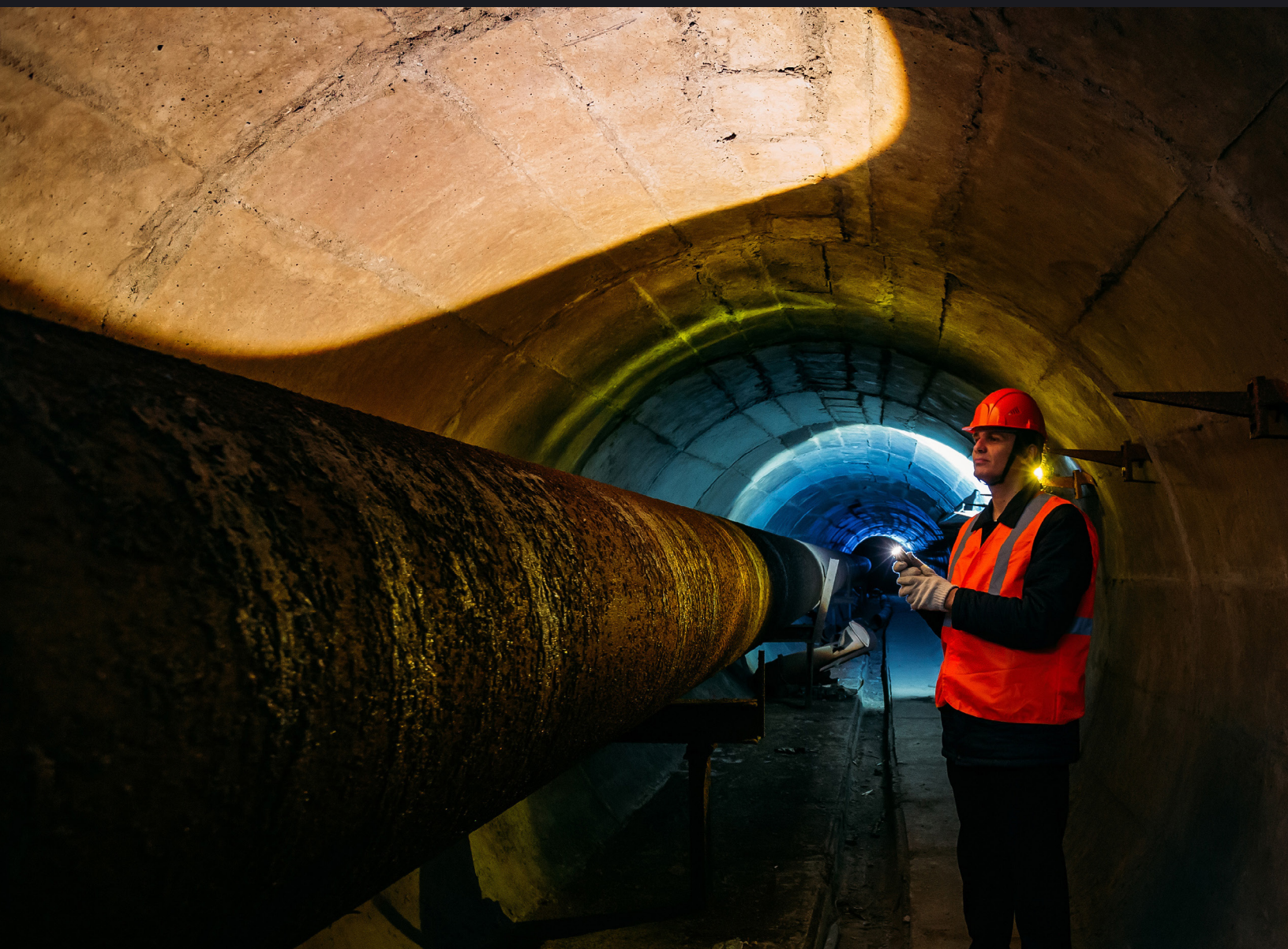
EBOOK

The digital operations playbook for mining in EMIA

How EMIA miners are closing the gap between physical operations and digital intelligence



Executive Summary

Since the beginning of the decade, the Western world has been rediscovering how critical mining is to its strategic independence and to its way of life. Under the assumptions of globalized free trade, it was cheaper and easier to outsource the entire mining value chain to developing nations and rely on global supply chains. Recent years have exposed the limits of that view. International tensions have revealed how fragile those supply chains were, precisely as demand for lithium, cobalt, nickel, copper and rare earths surged to meet the needs of the energy transition and defense build-ups.

At the same time, the fundamentals of the business are getting harder. Ore grades at established operations are declining, energy and labor costs are rising, capital projects overrun with depressing regularity and the workforce that built institutional knowledge across these operations is retiring, without adequate systems in place to capture what they know.

These trends have been compounding for a long period. What is new is the widening gap between what technology can now do and what most EMIA operations are actually doing with it. Predictive asset management, digitized operating procedures, connected operations centers, AI-assisted maintenance scheduling: these are deployed, working and generating measurable returns at mines across the region today.

This report examines five structural pressures bearing down on EMIA mining, sets out what a mature digital operation looks like in practice and draws on case studies from several large players across the region to identify how to successfully rewrite the playbook for the digitization of mining operations.

Five pressures reshaping EMIA mining

The case for operational change in EMIA mining does not rest on a single trend. It is driven by five structural pressures that are converging and bound to last.

1. Ore grade decline

Across the global mining industry, declining ore grades force operators to move more rock, consume more energy and manage larger waste volumes to recover the same amount of metal, which raises costs and puts additional pressure on operational planning. The average grade of copper ore, for example, has declined 40% since 1991, according to the International Energy Agency.

This is the defining operational challenge for established producers: costs rise while output either stagnates or falls.

The response is not straightforward. Deeper mining means harder ground conditions and more complex logistics; Wider open pits mean greater environmental impact, longer haul cycles and higher energy consumption. Companies are increasingly exploring advanced technology to compensate for declining asset productivity; in an effort to identify where the best ore is, when equipment is approaching failure and where resources are being wasted in the extraction, hauling and processing chain.

2. Capital project execution

Mining's record on major project delivery is poor. McKinsey found that 83% of major mining and metals projects exceed planned CapEx by more than 40%, with average schedule overruns of 20 to 30%.

These numbers matter particularly in EMIA because the region is entering a wave of capital deployment. In a country like Kazakhstan, the mining sector saw capital investment grow 20% in 2024, reaching $3.6 billion. African governments are pursuing resource industrialization strategies that will require substantial new infrastructure. European miners are investing in recycling capacity and secondary processing to meet the EU's Critical Raw Materials Act targets.

Given the high stakes, what are the main causes for project overruns?

One of the primary drivers is poor information management during project execution. It can lead, for example, to scope creep going undetected or to poor handover from project to operations that can result in safety risks and poor human performance for several years.

2.5%

Only 2.5% of large capital mining projects are considered fully successful against original scope, schedule, cost and business case targets

(Source)

3. Energy and cost pressure

The Deloitte Tracking the Trends 2026 report notes that since 2011, the net profit margin of the mining industry's 40 leading companies has fallen from 24% to around 10%, driven not only by commodity price movements but by rising costs against a background of grade decline.

Among the chief culprits is energy, which represents 20 to 40% of operating costs at most hard rock mining operations. Across EMIA, energy prices have been volatile since the start of the war in Ukraine in 2022.

Getting energy consumption under control requires granular operational data: which assets are running inefficiently, which processing circuits can be optimized, where scheduling decisions are creating avoidable peaks.

4. Workforce and knowledge loss

A McKinsey survey found that 86% of mining executives report greater difficulty recruiting and retaining skilled workers, particularly in mine planning, process engineering and data science. In the same survey, seven in ten mining leaders say that this talent shortage affects their ability to deliver on their production targets and strategic objectives.

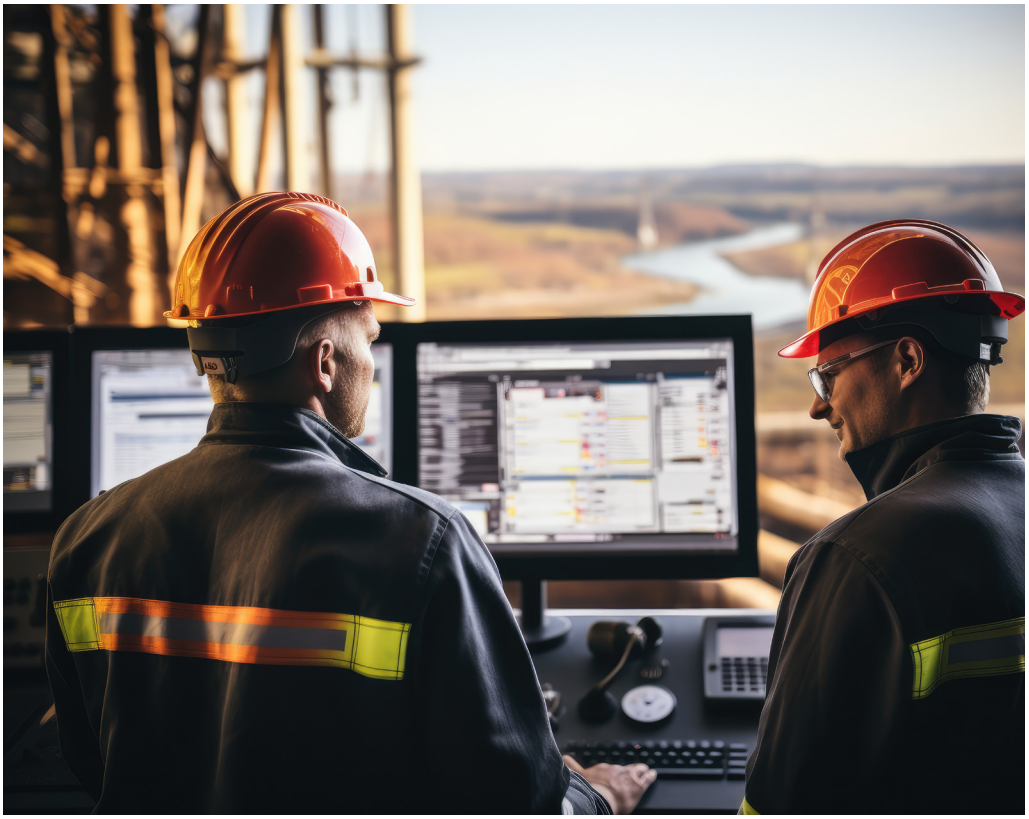
The deeper problem is knowledge retention rather than recruitment alone. When standard operating procedures live in paper binders and shift handover is done verbally, deviations get handled through individual judgment rather than captured by the system. Operations that invest in structured knowledge capture (digitized procedures, formal shift management, decision support tools) convert individual expertise into institutional capability.

5. OT cybersecurity

As mining operations become more connected, the attack surface grows. The MM-ISAC Annual Report 2024 recorded a tripling of reported cyberattacks against the mining and metals sector, from 10 incidents in 2023 to 30 in 2024. MM-ISAC's CEO notes that these figures likely understate the problem due to significant under-reporting.

The broader OT landscape is similarly alarming: Forescout's 2025 Threat Roundup found that attacks on OT protocols surged 84% in 2025, reviewing more than 900 million attacks globally.

For mining, the specific risk is the convergence of IT and OT systems that accompanies digitalization. Control systems for conveyor belts, crushers, concentrators and tailings management are increasingly connected to corporate networks. An attack on OT systems at a mining operation could disable processing circuits, corrupt production data or compromise safety systems. The EU's NIS2 Directive now applies to mining and metals companies handling critical raw materials, creating compliance obligations that many operators are unprepared for.



EMIA in context

The five pressures above play out differently depending on geography, commodity and operational maturity. Across the region, three distinct dynamics shape how the digital case is made and at what pace.

Africa: high stakes, infrastructure constraints

Africa holds an extraordinary concentration of critical mineral resources, but the operating environment presents challenges absent in Europe or Central Asia. Many of Africa's richest mineral deposits are landlocked and remote, lacking the roads, rail, water and power that mines require – a situation epitomized by the Democratic Republic of Congo, whose infrastructure is notoriously inadequate relative to the scale of its resources. Even South Africa, the continent's most industrialized economy, has not been immune: years of rolling power cuts forced production curtailments, raised operating costs and left investment planning in a state of chronic uncertainty.

Such factors mean that mining's digital transformation in Africa must be designed differently: edge computing architectures that process data locally, mobile tools that work offline and training programs designed for the actual workforce. The cost case for doing so is strong. South Africa's corporate tax revenue from mining has fallen sharply as commodity prices have declined and costs have risen, creating acute pressure on operating efficiency. Predictive maintenance and asset performance monitoring tools offer some of the highest-return investments available to South African operators, precisely because the cost of unplanned downtime in an energy-constrained environment is disproportionately high.

Middle East: building from a blank page

The Middle East is investing in mining as a core economic diversification strategy. Saudi Arabia's Vision 2030 ambition to make mining the country's third economic pillar is backed by an estimated $2.5 trillion in mineral assets. In 2025, Saudi Arabian miner Ma'aden signed a four-year agreement with Fleet Space Technologies and Saudi integrator Tahreez to deploy AI-powered mineral exploration across 12,000 square kilometers of the Arabian Shield, combining low-earth-orbit satellites, ground sensors and AI targeting.

The advantage of building new operations is that digital architecture can be designed from the outset. The challenge is that operational expertise and institutional knowledge take decades to accumulate. Workforce capability development is the long-term constraint and it cannot be resolved by technology alone.

Europe and Central Asia: established operations under margin pressure

European mining operates under long permitting processes, community scrutiny and high labor costs relative to other jurisdictions. The EU's Critical Raw Materials Act has created policy support for domestic production, but it does not change the underlying economics: most European mineral projects need to be more efficient than their competitors to be viable.

Secondary processing, recycling infrastructure and downstream integration are increasingly part of the strategic picture.

Central Asia as a region holds a more comfortable position, though the pressures are real and varied. Kazakhstan dominates by scale: its mining sector accounts for 29% of the country's industrial output and 7% of GDP, with capital investment growing 20% in 2024. But Uzbekistan has emerged as a significant force in its own right. State-owned Navoi Mining and Metallurgical Company operates Muruntau, the world's largest open-pit gold mine, and generated revenue of $7.4 billion in 2024, equivalent to around 6.4% of Uzbekistan's entire GDP. The company surpassed Russia's Polyus in 2024 to become the world's fourth-largest gold producer, and has announced plans to increase output by 30% to approximately 4 million ounces by 2030. Kyrgyzstan and Tajikistan are smaller but increasingly active, with both governments lifting restrictions on mineral development and attracting foreign investment in gold, antimony and rare earth projects.

What unites these producers is a familiar operational pressure: established mines are aging. Ore grades are declining across multiple commodities and jurisdictions, meaning throughput must increase just to maintain output levels. Processing more ore for every unit of metal produced multiplies pressure across the entire operation: on equipment reliability, maintenance cycles, energy consumption and the workforce.

What a mature digital operation looks like

The term “digital mine” is at least a quarter of a century old, initially appears in Chinese mining engineering literature around 2000 before moving to the English-speaking world. Like any technology concept with such a longevity, it can seem overused and imprecise. What is more useful is a clear picture of the core capabilities that distinguish operations with genuine digital maturity from those running disconnected point solutions that do not change how decisions get made.

There are four capability areas where the evidence of operational impact is strongest: asset performance and maintenance, digital operations management, engineering information integrity and industrial cybersecurity. They address different pain points across mining operations, and they build on each other.

Asset performance and maintenance

Most EMIA mining operations still manage maintenance through time-based schedules and reactive interventions. When equipment fails, production stops while the team identifies and repairs the fault. The cost of such reactive practices goes beyond the repair itself: unplanned downtime, accelerated secondary failures, emergency parts procurement and overtime to recover lost output all compound the damage. Enterprise asset management, implemented properly, changes this model. Octave Attune EAM provides the structured foundation: asset registry, work order management, preventive maintenance scheduling, spare parts inventory and cost tracking. Octave Attune APM layers risk-based assessments, condition monitoring and predictive analytics on that foundation. Vibration signatures, thermal readings, oil analysis data and operational parameters feed into models that identify degradation trends before failure occurs.

At a concentrator operating around the clock, the difference between planned and unplanned maintenance is substantial. A planned mill liner replacement takes four hours. An unplanned failure of the same component, with secondary damage to the mill shell, can take 48 hours and require specialist welding that may not be available on site. Predictive maintenance does not eliminate all failures; it significantly shifts the distribution toward the planned end, where the organization has time to prepare and downtime is minimized.

50%

Almost of mining companies plan to invest in predictive maintenance in the next two years

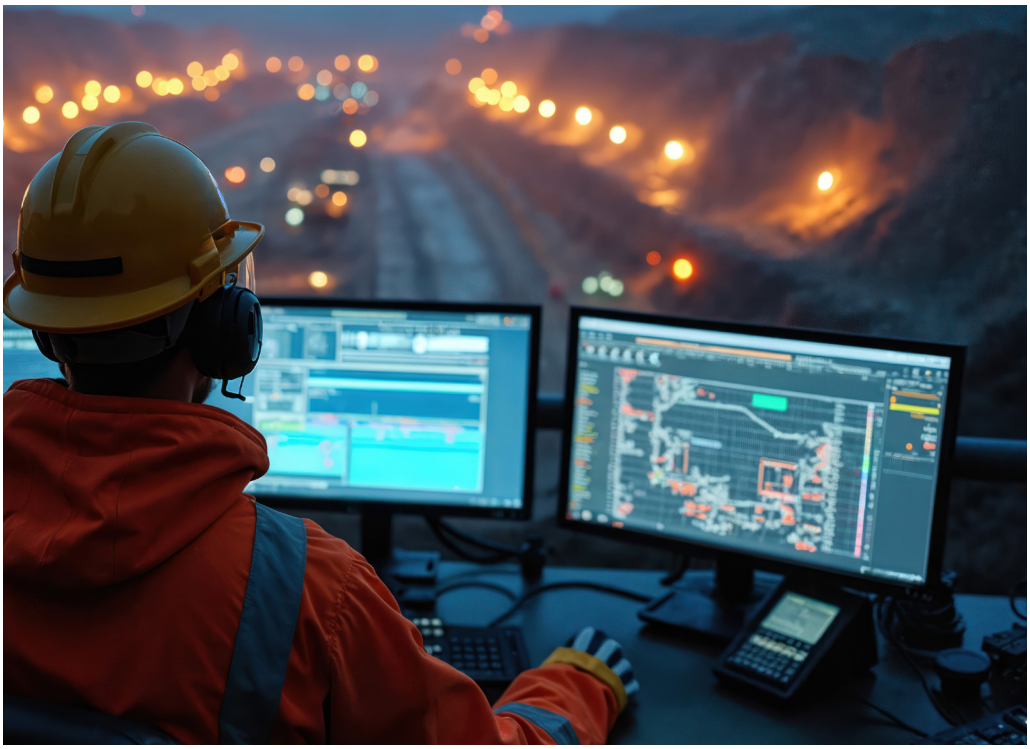
(GlobalData, 2025)

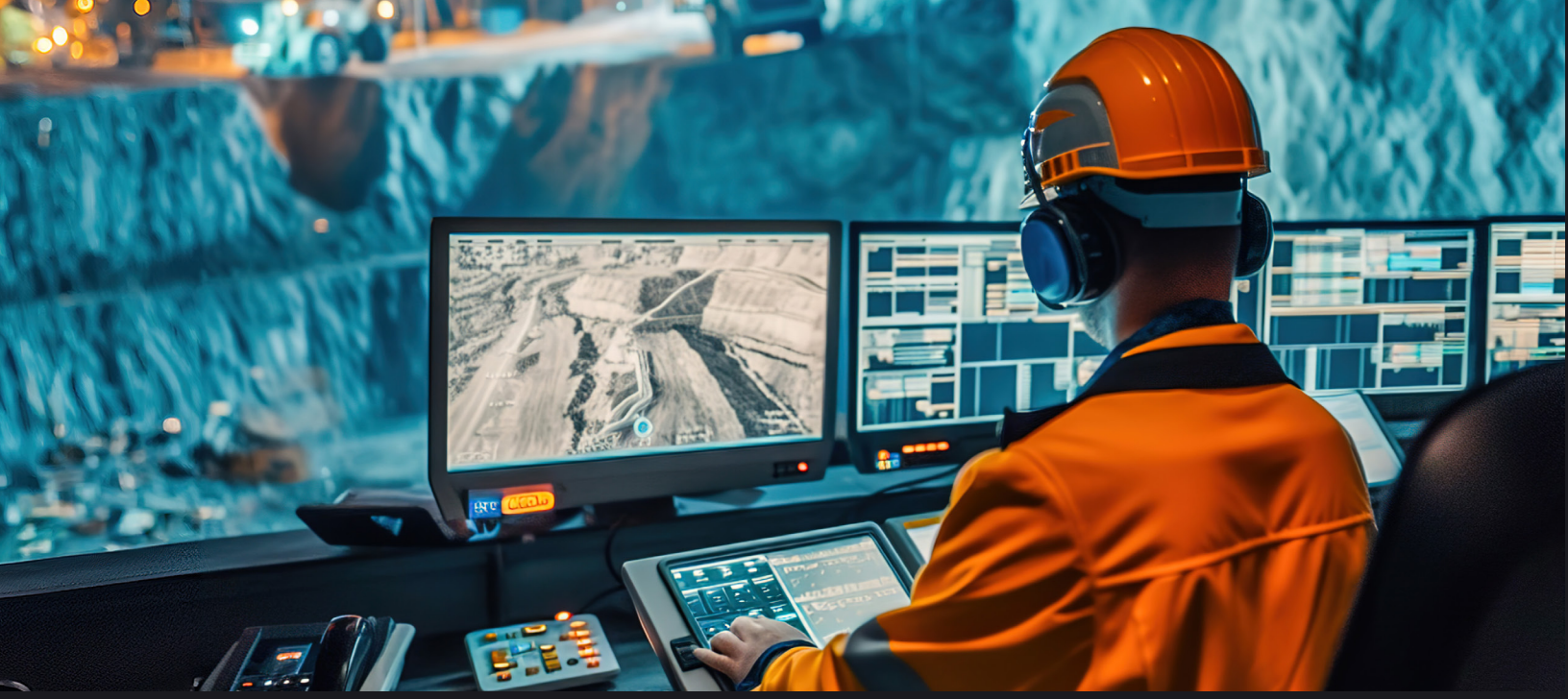
Digital operations management

The quality of how work is actually done, shift by shift, is more important than it appears. Octave Tempo addresses this through three connected functions. Operating procedures management digitizes and version-controls the instructions governing how equipment is operated, how maintenance tasks are performed and how safety requirements are met. Instead of binders on a control room shelf, procedures are accessible on tablets at the point of work, with step verification and deviation capture. Shift handover management replaces untraceable verbal briefings with structured digital logs that carry forward open issues, safety observations and equipment status. Control of Work digitizes the permit-to-work process, which governs who can work on what equipment and under what conditions.

The solution addresses well-documented classes of operational risk: when maintenance technicians cannot locate the current version of a procedure, they often rely on their own judgement or on available paper copies, which may not reflect a change made months ago. Similarly, when shift handover is verbal, context gets lost and miscommunications abound. When permits are paper-based, conflicting work authorizations can be issued without either supervisor knowing it. These are documented causes of a significant proportion of mining incidents and production losses.

Octave Tempo Control System Effectiveness adds automated monitoring of whether control system setpoints are being followed, flagging deviations for review. In a processing plant with dozens of interdependent circuits, knowing in real time that a primary crusher is running outside its optimal parameters is more valuable than finding out at the end of shift.





Customer Spotlight

Aktogay: shift continuity and operational visibility at a large copper operation

The Aktogay copper mine in Kazakhstan's Abay region is one of the most significant open-pit copper operations in Central Asia. Owned by KAZ Minerals, it features two sulphide concentrators with a combined design capacity of 50 million tonnes per year.

Running a concentrator complex of this scale continuously, across three shifts, creates specific challenges around knowledge transfer and continuity. At a mine of this size, the quality of shift handover determines whether the incoming team has a clear picture of where the plant stands: what was running, what is in a degraded state, what maintenance work was initiated and what the processing targets are for the next eight hours. If that transfer is incomplete or verbal, the incoming team spends the first part of its shift reconstructing context rather than operating the plant.

The deployment of Octave Tempo Operations Management at Aktogay addressed this directly. Digital shift handover replaced verbal briefings with structured, searchable records that carry forward open items, equipment status and operational deviations. Standard operating procedures were digitized and made accessible at the point of work. Control room operators gained a consistent view of plant status that did not depend on what the outgoing shift chose to communicate.

The operational impact goes beyond convenience. When a concentrator runs continuously above design capacity, the margin for error in shift management is narrow. A missed handover item leading to the wrong feed rate being maintained into the next shift can take hours to detect and correct. Structured digital handover reduces the frequency of these continuity failures and makes those that do occur faster to identify and address.

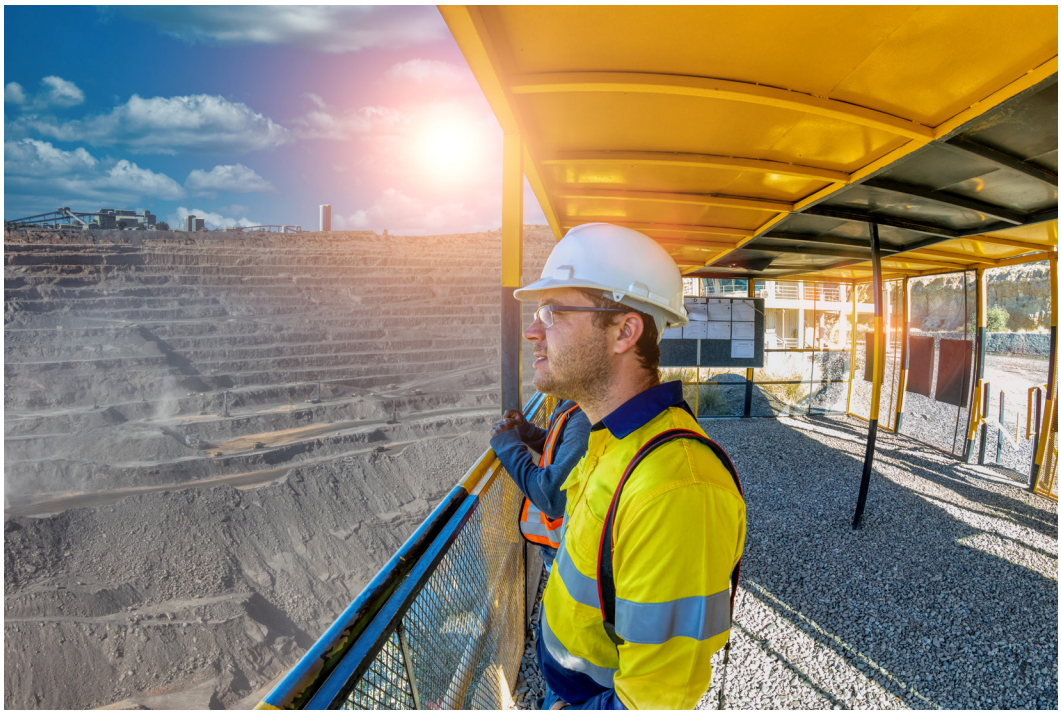
Engineering information integrity

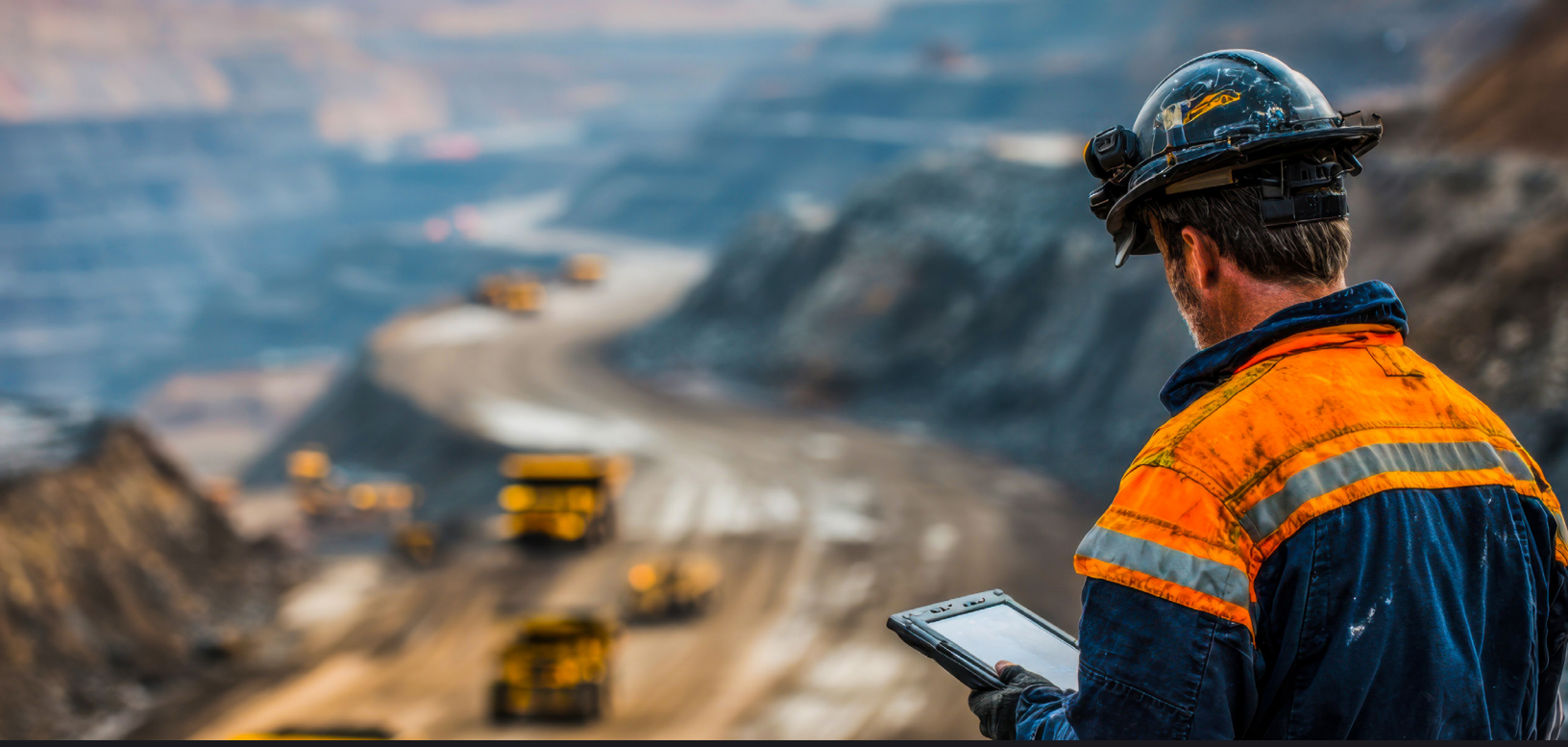
A persistent problem across mining operations is the quality of engineering information – whether it's drawings that do not reflect what was actually built or maintenance procedures written for equipment that was replaced.

Octave InConcert provides the document and data management backbone that connects engineering information to operational workflows. When a maintenance work order references a valve, it links directly to the valve's engineering drawings, maintenance history, spare parts list and operational procedure. The value becomes most visible during capital projects and turnarounds: when a concentrator undergoes a major scheduled shutdown, the quality of work order preparation determines whether the shutdown comes in on time and on budget. Poor engineering information means technicians discovering mid-work that drawings do not match reality, parts ordered are the wrong specification or the task sequence creates conflicts. Better information management converts these avoidable surprises into planned activities.

Industrial cybersecurity

Octave Cyber Integrity addresses OT cybersecurity through purpose-built capabilities: visibility into what is connected on the OT network, identification of vulnerabilities in industrial control system software and firmware, and monitoring for anomalous behavior that could indicate compromise. Industrial control systems were designed for reliability, not security. They run proprietary protocols, cannot be patched on the same schedule as IT systems because they run continuous processes, and are increasingly connected to corporate networks as digitalization advances. For European operators, Octave Cyber Integrity also addresses the NIS2 compliance obligations now applicable to organizations handling critical raw materials. The compliance argument and the operational risk argument lead to the same conclusion: OT security needs to be built in as digital capability is deployed, not added afterward.





Spotlight

How Carmeuse broke down silos

Carmeuse is a Belgian mining and minerals company founded in 1860. It operates 90 plants and 60 limestone quarries across Europe, North America and Africa, employing approximately 6,300 people and generating revenues of around €2.5 billion. Its products (high calcium lime, dolomitic lime and calcium hydroxide) go into steel production, water treatment, flue gas desulfurization and construction.

Before implementing a connected asset management platform, Carmeuse's maintenance operations reflected a pattern common to companies that grow through acquisition: each site had its own way of doing things, maintenance data lived in multiple systems and procurement decisions were made locally, without visibility into available inventory at other sites. Management had limited visibility into asset health across the portfolio.

The transformation program centered on deploying Octave Attune EAM as the common platform across sites. The work required more than software implementation: it entailed standardizing how assets were described, how maintenance tasks were classified and how data would be captured at the point of work. This standardization created cross-site visibility that had not existed before.

The decision to implement Attune EAM paid dividends as overtime dropped and maintenance became more planned and less reactive. Equipment availability also improved as preventive work was completed on schedule rather than deferred and procurement decisions became more informed because managers could see inventory levels across sites. Senior leadership gained a consolidated view of asset health across the whole portfolio, changing the quality of conversations about capital allocation and maintenance investment.

The road forward

The mining industry is not short of technology. In many cases, it is short of the organizational capability to convert technology investment into operational change. This distinction matters because it changes the nature of the challenge and the appropriate response.

Technology pilots are relatively easy to run: condition monitoring on a few assets, a predictive maintenance algorithm on historical data, a digital handover tool trialled on a single processing plant: these are achievable in months. The harder work is building the data governance, workforce capability, process discipline and integration architecture that allows point solutions to become systemic capabilities.

The Deloitte Tracking the Trends 2026 report identifies this precisely: companies risk getting caught in an endless loop of “exploring” and “doing” rather than reaching genuine digital maturity. The distinction between those stages is not about the sophistication of the technology deployed, but about whether digital tools are changing how decisions are made, how problems are identified and how knowledge is retained.

For EMIA operators, three practical conclusions follow.

Start with information integrity

The most common failure mode in digital transformation programs is building analytics on top of poor data. Asset registers that are inaccurate, maintenance histories that are incomplete, engineering drawings that do not reflect what was built: these are not solved by adding more technology. Getting engineering and asset information into a reliable, structured state is unglamorous work, but it is what everything else depends on.

Sequence capabilities logically

There is a natural progression in digital capability building for mining operations. Asset management and operating procedure digitization come first, because they generate the data and workflows on which everything else depends. Predictive maintenance and condition monitoring come next, because they require baseline data to be meaningful. Integrated operational visibility and AI-assisted optimization follow, because they require the lower layers to be working. Organizations that try to jump to the top of this stack without building the foundation find that the advanced capabilities underperform.

Treat cybersecurity as infrastructure

The NIS2 Directive has made OT cybersecurity a compliance issue for many European mining companies. But the argument does not rest on compliance alone. As operations become more connected, the consequences of a successful attack on OT systems become more severe. Building cybersecurity into the connected operations architecture from the beginning is both technically easier and financially more efficient than retrofitting it at the end.

The structural pressures on EMIA mining are not going away. Ore grades will continue to decline and energy costs will remain elevated for the foreseeable period. The workforce knowledge gap will widen long before it narrows and capital projects will continue to overrun unless information management improves.

The tools to address these pressures exist. The operators that will perform best over the next decade are those that build the organizational discipline to use them consistently, connect them into a coherent operational architecture and develop the workforce capability to act on what the data tells them.

About Octave

Octave is a leader in enterprise software, turning data into decisive action and intelligence into your edge. Our software solves for and simplifies complexity, from the design and build to operations and protection of people, property, and assets – for any scope, at any scale. For decades, we've partnered with customers to sharpen performance, elevate efficiency, and amplify results. From factory floors to entire cities, our solutions are tuned to scale up what's possible from day one onward.