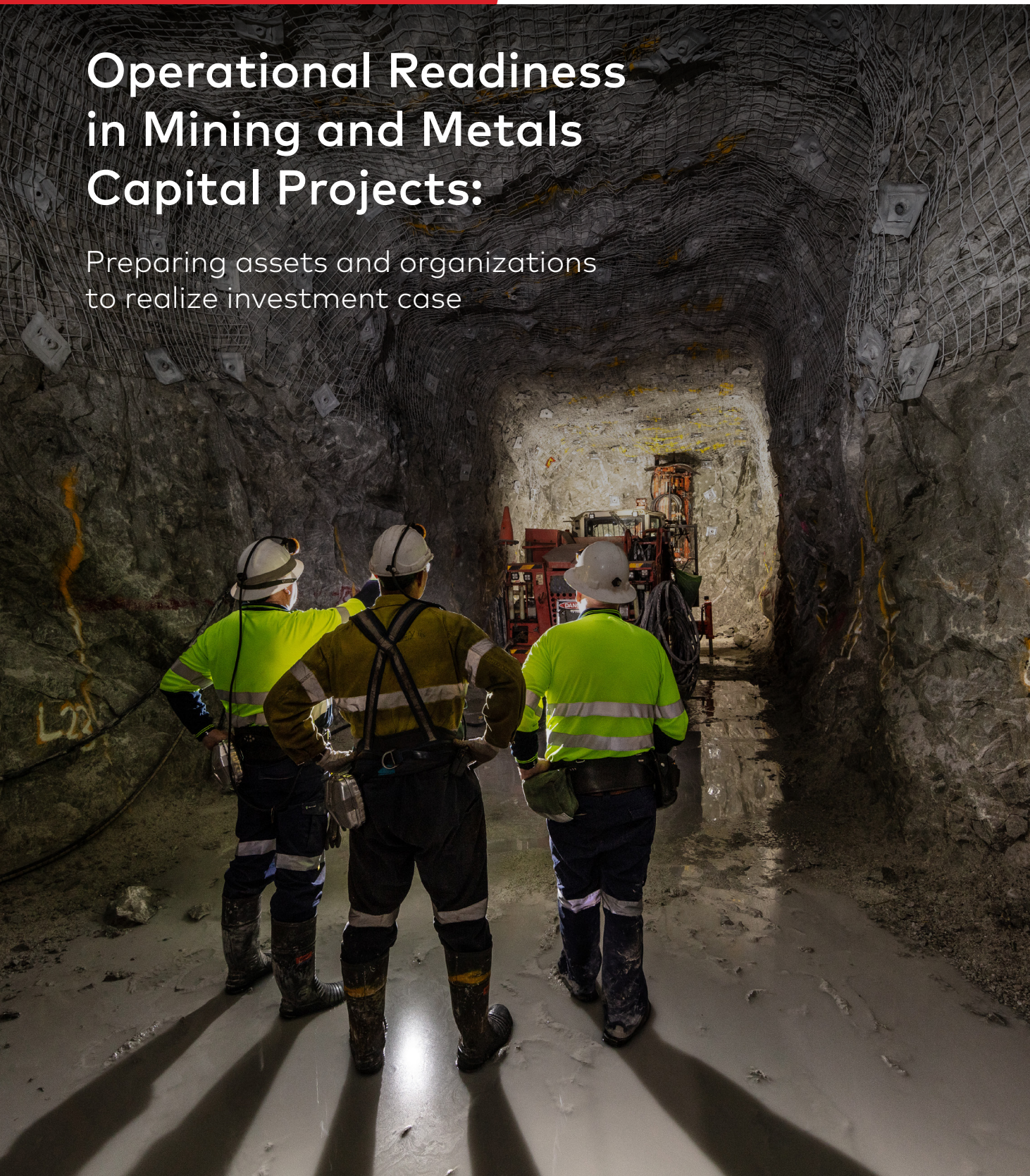


Operational Readiness in Mining and Metals Capital Projects:

Preparing assets and organizations
to realize investment case



dss⁺

Protect. Transform. Sustain.

Capital invested in a mine, processing plant, smelter or refinery generates its expected return only when the asset operates safely, reliably and at the required level of performance. Construction completion and commissioning are necessary milestones, but neither physical completion nor completion of readiness activities is sufficient evidence that the asset and operating organization can perform under the conditions they will encounter. Operational readiness provides the owner with a structured process for defining those conditions and confirming that the asset, systems, controls and organization function in practice. Without that evidence, ramp-up may be prolonged, production and revenue deferred, operating costs increased and start-up risks elevated.





VALUE AT STAKE DURING START-UP AND RAMP-UP

Production and revenue: McNulty's review placed only 23 of 81 mineral-processing plant ramp-ups, or 28%, in the best-performing profile¹. Assets that follow slower profiles generate less saleable production during their early operating period, delaying revenue and realization of the investment case.

Project value: For an asset with capacity of 1 million tonnes per year and a contribution margin of US\$100 per tonne, every 10-percentage-point annual capacity shortfall represents US\$10 million of contribution margin not generated. The loss is permanent where production cannot be recovered within the resource life, licence term or available market window. Delayed production also reduces NPV because cash inflows occur later while start-up and operating costs continue.

Cost of reaching stable operation: RAND's study of 51 U.S. process plants reported a four-month median and an eight-month mean start-up period. The corresponding reported start-up cost values were 3.6% and 5.5% of construction capital³. The difference between these values is 1.9 percentage points, equivalent to US\$19 million for a US\$1 billion project.

Safety and continuity: The U.S. Chemical Safety Board has cited refining-industry research indicating that 50% of process-safety incidents occur during start-ups, shutdowns and other infrequent events⁴. A serious event during start-up can harm personnel, damage the asset, interrupt ramp-up and defer production and revenue. Operational readiness, including PSSR for high-hazard processing facilities, provides assurance that hazards, safeguards, procedures and workforce capability have been established before start-up.

In **Securing Net Present Value through Culture by Design and Systems of Work**, dss+ described how owner-led Culture by Design and Defined Systems of Work can improve the delivery of large mining and metals capital projects. Operational readiness carries these principles through commissioning, start-up and ramp-up so that they become part of the future operating organization rather than ending at project handover⁸.

The relationship between readiness and ramp-up

McNulty's ramp-up profiles show the different rates at which mineral-processing plants achieve design capacity following commissioning. The best-performing profile is associated with mature or thoroughly tested technology, representative test work, well-developed engineering, an informed workforce, experienced supervision and adequate technical support during commissioning and ramp-up¹.

These conditions extend beyond the technical design of the asset. They include the capability of the people and organization that will commission, operate, maintain and support it.

Recent reviews of the McNulty case histories have reinforced this connection. Projects using proven technology have underperformed where constructability, operational readiness or start-up resourcing were insufficient. Conversely, projects involving new technology have achieved successful ramp-up where the technology was rigorously tested and supported by experienced teams⁵.

Mining and metallurgical industry research has similarly defined operational readiness as the process through which an asset is prepared to start effectively, ramp up as planned and transition into sustainable operation. The research concluded that many design and ramp-up problems are avoidable because they arise when projects fail to account for the requirements of the future operation during development and execution².

The relevance for mining and metals owners is that start-up and ramp-up are part of the investment outcome. They should be planned, resourced and governed with the same discipline applied to project execution.



THE dss+ POINT OF VIEW

Start by FEL-2: Operational readiness should begin while design, technology, operating-model and contracting decisions can still be influenced. For projects using a conventional FEL process, dss+ considers that this should be as early as FEL-2.

Maintain distinct accountability: A readiness team should work alongside the project team, with clear responsibility for preparing the future operation.

Address the full operating environment: Readiness should cover the asset, organization, culture, systems of work and supporting ecosystem, including foreseeable variations and constraints that could affect start-up and ramp-up.

Treat safety readiness as a condition of progression: The asset should progress to start-up or the next production stage only when hazards, controls, competence and emergency capability have been demonstrated.

Assess individual and team capability: Readiness should be based on evidence that people can apply the required systems, controls and procedures under normal, abnormal and emergency conditions, rather than on training or deliverable completion alone.

Retain owner accountability: The owner should sponsor and resource operational readiness, define operating and acceptance requirements, assure readiness across owner and contractor scopes, and retain authority for decisions to proceed into commissioning, start-up and production.



Culture and systems of work through ramp-up

Ramp-up is not only the period in which the asset progresses towards design capacity. It is also the period in which the organization, management systems and working practices established during project delivery are transferred to and tested by the operating organization.

Culture by Design is an owner-led process for translating organizational values into expected behaviours and aligning the owner team, project-delivery partners, contractors and future operations team⁸. Operational readiness should carry these expectations into organization design, workforce selection, onboarding, leadership routines, contractor management and performance management.

Defined Systems of Work provide the routines through which these expectations are applied⁸. During ramp-up, the owner should verify that planning, shift handovers, interface management, decision and escalation paths, performance information, risk controls and management routines are functioning under actual operating conditions.

Evidence should come from the way work is performed. The owner should consider whether responsibilities are clear, risks and constraints are identified early, decisions are timely, performance information is reliable, and safety, production, maintenance, technical support and contractor activities are adequately coordinated.

Lessons from ramp-up should be used to make controlled improvements to routines, interfaces, accountabilities and expected behaviours. This support should continue until the owner has evidence that the operating organization can sustain the required performance. The duration should reflect the asset's complexity, risk and ramp-up profile rather than a fixed period.

Operational readiness should address the conditions that affect ramp-up

Ramp-up may be affected by ore and feed characteristics, technology maturity, engineering, equipment performance, construction quality, commissioning, utilities, logistics and operating capability.

These conditions should not be treated as matters for the operating organization to discover and resolve after start-up. Operational readiness should ensure that they are understood, tested and incorporated into the design, operating model, ramp-up plan and supporting capabilities.

The scope should reflect the asset, technology, location, operating model and risk. It should not be based on a fixed list applied in the same way to every project. Depending on the project, the readiness scope may include:



Resource, ore and feed characteristics, including characterization, mine planning, blending strategies and response to expected variability.



Asset and system readiness, including operability, maintainability, reliability, system completion and controlled management of incomplete work.



Safety, environmental and stakeholder readiness, including hazard assessment, critical controls, operating limits, emergency capability, regulatory requirements and commitments made to communities and other stakeholders.



Contractor, commissioning and ramp-up readiness, including interfaces, acceptance conditions, technical support and stabilization arrangements.



Process and technology maturity, including test work, scale-up assurance, design margins and specialist support during ramp-up.



Organization and workforce readiness, including accountabilities, organizational values, expected behaviours, workforce availability, recruitment and retention assumptions, individual competence, team capability, supervision, transitional leadership arrangements and operating culture.



Systems of work and operating support, including owner-controlled planning, governance, interface management, decision and escalation paths, performance measures, management routines, maintenance and reliability systems, critical spares, materials, utilities, logistics, supply chains, and information and digital systems.

Operational readiness does not require the readiness team to perform the work of the geologist, metallurgist, engineer, constructor or equipment supplier. It requires the owner to integrate and assure their contributions against the conditions needed for successful operation.

Where a reasonably foreseeable variation causes an avoidable ramp-up delay, the asset or organization was not fully ready for the conditions it was expected to manage.



INDICATORS THAT OPERATIONAL READINESS MAY BE AT RISK

Operational readiness may require additional attention where:

- No readiness leader or core team has been established by FEL-2, or the equivalent stage.
- No approved operational-readiness plan is in place by FEL-3, integrated with the project schedule and decision gates.
- The required readiness outcomes, deliverables, acceptance criteria and supporting evidence have not been clearly defined.
- Readiness is managed entirely within the project team without distinct accountability for the future operation.
- The intended culture and systems of work have been defined for project execution but have not been translated into the future operating organization.
- The required start-up capability and support model have not been defined, including competence for abnormal conditions, troubleshooting, critical-control management and access to specialist support.
- Readiness is measured mainly through completed documents and training records, without evidence that individuals and teams can apply them in practice.
- Readiness is left to the project-delivery team or future operating contractor without defined owner assurance, acceptance criteria and decision authority.
- Ramp-up assumptions have not been tested against ore variability, technology, utilities, workforce and supply-chain conditions.
- Safety-readiness reviews are planned as late compliance activities rather than evidence-based decisions.
- Readiness activity is expected to finish at handover rather than continue through ramp-up and stabilization.

Starting operational readiness as early as FEL-2

dss* considers that operational readiness should begin as early as FEL-2. At this stage, the project concept is sufficiently developed for the future operating requirements to be defined, while design, technology, operating-model and contracting decisions can still be influenced.

Organizations that do not use the FEL framework may describe this stage differently. The underlying principle is to begin operational readiness during pre-feasibility or early project definition, before the main assumptions affecting the future operation have been fixed.

At this stage, the owner should begin defining the intended culture and the systems of work required for both project delivery and future operation. This allows the owner's safety philosophy, operating model, environmental and social commitments and long-term strategy to influence project scope, execution and contracting decisions before they are fixed.

At FEL-2, a small core team can establish:

- The operating and maintenance philosophy.
- The principal operating, safety and critical-control requirements that need to influence the design.
- Initial assumptions for the organization, workforce and capabilities required during commissioning, start-up, ramp-up and steady-state operation, including the allocation of owner and contractor responsibilities.
- The intended operating culture, including how organizational values will translate into leadership expectations, management practices and day-to-day behaviours.
- Requirements for infrastructure, logistics, supply chains, information and supporting systems.
- The readiness strategy, governance, scope, accountabilities and integrated plan.
- The basis for commissioning, start-up, ramp-up and stabilization, including the temporary leadership and technical support required during the transition.

This does not require a fully staffed operating organization or the detailed development of every readiness deliverable.

Early operating involvement also allows reasonably foreseeable variability to be addressed before the asset is built. The readiness team can challenge whether the proposed design, operating model and supporting arrangements are suitable for the orebody, feed conditions, technology, location and operating environment that the asset is expected to encounter.

Maintaining distinct readiness accountability

The project team and operational-readiness team should work closely, but their principal accountabilities are different.

The project team is responsible for delivering the approved physical scope. Its controls generally focus on engineering, procurement, construction, commissioning, cost, schedule, quality and technical completion.

The operational-readiness team is responsible for preparing the organization that will accept and operate the asset. Its focus includes people, systems, operating processes, controls, interfaces and the evidence required to demonstrate readiness.

The difference in accountability creates a potential tension in priorities and time horizons. Project controls emphasize delivery of the approved scope within cost and schedule, while the operating organization must determine whether people, systems and controls can sustain safe and reliable performance after handover. Under delivery pressure, readiness activities may be reported as complete even though the capability or control they are intended to establish has not been demonstrated. A distinct readiness team gives the owner a separate line of sight to this risk.

The readiness team should therefore be distinct from, but integrated with, the project team. It should have a named leader and executive sponsor, defined access to project decisions, appropriate functional representation, an integrated schedule and authority to escalate gaps through project governance.

These arrangements should remain owner-led. The owner may use EPCM, contractor or specialist resources to complete readiness activities, but should retain responsibility for the readiness strategy, acceptance criteria, assurance process, unresolved gaps and the decision to proceed into commissioning, start-up or production.

The owner should also define how accountability will transfer from the project director to the general manager or operations leader. The timing, acceptance conditions and decision authorities for this transition should be established before commissioning. During the transition, there should be no ambiguity about who controls the asset, accepts residual risk or authorizes progression to the next stage.

Assuring capability for start-up and operation

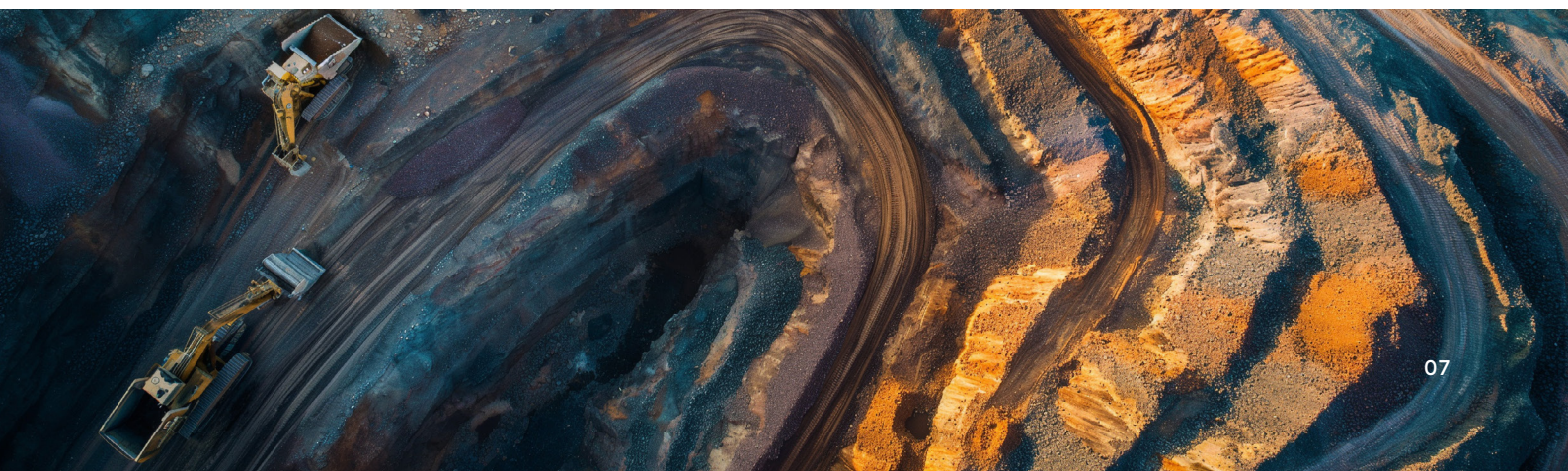
Capability readiness is one component of operational readiness. Operational readiness also includes the asset, systems of work, risk controls, operating processes, supporting functions and interfaces needed to achieve the intended operating outcome.

Competence applies to the knowledge, skills and behaviours required for an individual role. Organizational capability is broader. It depends on whether people can use the available procedures, controls, equipment, information, supervision and technical support to perform effectively as a team under the conditions the operation will encounter.

The required capability changes in emphasis during the transition to operation. During commissioning, start-up and early ramp-up, operating conditions are less stable and teams may encounter equipment, process and interface problems that have not yet become routine. Operators, maintainers and supervisors need to understand the design intent, operating limits, principal hazards and critical controls. They also need to recognize abnormal conditions, diagnose problems, take appropriate action, escalate decisions and coordinate specialist support.

During stable operation, greater emphasis can be placed on consistent execution, production and maintenance routines, reliability and performance improvement.

The capability to manage abnormal conditions and protect critical controls should nevertheless be retained.



The owner should therefore define both the future steady-state organization and the transitional capability required during commissioning, start-up and ramp-up. This includes decision authority, experienced supervision, shift coverage, access to project and commissioning knowledge, vendor or specialist support, and the criteria for reducing transitional support.

Capability should be defined, developed, demonstrated and sustained as the asset progresses from project development through start-up, ramp-up and stable operation.

Capability Assurance stage	Typical timing	Expected Evidence
Defined	Project development	Critical roles, start-up and steady-state capability requirements, decision authorities and assurance methods are defined.
Developed	Project execution and pre-commissioning	People are recruited and prepared; procedures, tools, supervision and technical support are available.
Demonstrated	Commissioning and start-up	Individuals and teams demonstrate that they can apply critical controls, manage abnormal conditions, troubleshoot problems and coordinate specialist support.
Sustained	Ramp-up and stable operation	Performance is monitored, gaps are addressed, routines are embedded and transitional support is reduced against agreed criteria.

Completion of training, procedures and governance activities does not, on its own, demonstrate capability. Evidence may include role-based assessments, scenario exercises, emergency drills, field observation, supervised task performance and formal authorization for critical activities. These activities should test individual competence and team performance, as well as whether procedures are workable and whether decision rights, escalation paths and technical-support arrangements function under realistic start-up conditions.



TESTING A CRITICAL CONTROL UNDER OPERATING CONDITIONS

At an underground coal operation, a proximity detection system was installed on shuttle cars, supported by procedures, assigned ownership and operator training. Once production began, steel mesh used for ground support interfered with the system and caused repeated equipment trips. The control had been installed and documented, but its effectiveness had not been demonstrated under representative operating conditions. The example shows why readiness assurance should confirm that controls function in the intended environment and that the operating organization can respond appropriately when performance differs from design.

Safety readiness should reflect the asset and transition

Safety readiness applies across mining and metals capital projects, but the point at which it is demonstrated differs between fixed processing facilities and mining operations.

Processing plants, smelters and refineries

For a processing plant, smelter or refinery, start-up is a recognizable but non-routine operating condition. Equipment and systems may be operating for the first time, temporary arrangements may remain, and construction, commissioning and operating activities may overlap.

The U.S. Chemical Safety Board has cited refining-industry research indicating that 50% of process-safety incidents occur during start-ups, shutdowns and other infrequent operating events.⁴ This concentration demonstrates that readiness cannot be assessed only against routine production.

Before hazardous materials or energy are introduced, the owner should have evidence that hazards have been assessed, equipment conforms to the design basis, critical safeguards are functional, procedures are adequate, personnel are competent, emergency arrangements have been tested and incomplete or simultaneous work is controlled.

This requires more than confirmation that training has been completed. Operators and supervisors should be able to recognize abnormal conditions, understand the status of critical controls, respond within operating limits and use the required escalation, stop-work and emergency arrangements.

For high-hazard processing facilities, a pre-start-up safety review provides a formal means of confirming that these conditions

have been met. OSHA's process-safety requirements specify that the PSSR should confirm that equipment conforms to design, procedures are adequate, process-hazard recommendations have been addressed and required operator training has been completed⁶.

The PSSR is therefore part of operational readiness. It provides a final safety-assurance gate before the facility moves from commissioning into operation.

Mining operations

A mine may not have a single equivalent start-up point. Activities such as drilling, blasting, loading, hauling, mine development and infrastructure construction may be introduced progressively and continue throughout the operating life.

Safety readiness should therefore be demonstrated through staged reviews aligned with relevant development and production milestones. These may include transfer of an area to production control, commencement of production activities, introduction of a new mining area or operating method, activation of principal hazard-management systems and mobilization of a mining contractor.

Before each transition, the owner should verify the required critical controls, workforce and contractor competence, equipment readiness, emergency and rescue capability, operating accountabilities and management of incomplete or concurrent work. Where development, construction and production overlap, the review should also confirm who has operational control, which management system applies and who is authorized to accept residual risks.

In both fixed facilities and mining operations, the principle is the same: the operation should not progress until the owner has adequate evidence that the associated risks, controls and organizational capabilities are understood and functioning.

Retaining accountability for contractor-operated assets

Contractors increasingly perform substantial parts of mining and metals operations. In some arrangements, the contractor provides the workforce, equipment, supervision and management systems required to operate the asset.

This changes how readiness is executed, but it does not remove the owner's exposure if production, safety, environmental, regulatory or stakeholder requirements are not met.

ICMM's 2025 member data recorded 39 fatalities, 27 of which involved contractors, representing 69% of the total⁷. The data reinforce the importance of owner oversight where critical work and operational risk are managed through contracted organizations.

The contractor should prepare and demonstrate the people, equipment, processes and systems within its scope.

The owner should retain responsibility for:

- Defining the operating outcomes and minimum risk-control requirements.
- Specifying competence, supervision, reporting and escalation expectations.
- Managing interfaces between the owner, project team and contractors.
- Obtaining and verifying evidence that the contractor's arrangements are functioning in the field.
- Determining whether identified gaps are acceptable and monitoring capability through ramp-up and stabilization.

Readiness activities may be delegated within a defined scope. Accountability for accepting the operational exposure remains with the owner.



An approach grounded in owner-operator experience

The dss+ approach to operational readiness is grounded in owner-operator experience. Its practitioners include people who have held asset-owner and operational responsibilities.

This experience affects how readiness is approached. The focus is not limited to producing a framework, tracker or set of deliverables. It considers the decisions the owner will continue to face after handover:

- Whether the asset can be accepted at the stated level of risk.
- Whether the organization can manage expected operating variability.
- Whether the asset can sustain production and reliability.
- Whether contractors can perform under the owner's requirements.
- Whether unresolved work is controlled and assigned.
- Whether organizational values and expected behaviours are reflected in leadership routines and management systems.
- Whether the operation can respond when conditions differ from plan.

The approach is therefore based on the owner's continuing responsibility for the asset, workforce, operational risk and investment outcome. It reflects the perspective of an organization that must operate and maintain the asset after project contractors and external advisers have completed their assignments.



APPLYING THE APPROACH ACROSS A MINING AND METALS PORTFOLIO

dss* recently supported a diversified mining and metals group in developing an enterprise operational-readiness approach for mines, processing facilities, smelters, refineries and supporting infrastructure.

The work established common governance and assurance principles while allowing project-specific requirements to reflect the asset, technology, operating model and risk. The approach included early initiation during project development, distinct readiness accountability, implementation-based reviews and owner assurance of contractor readiness.

Implementation is being extended across the portfolio, providing a consistent basis for readiness ownership, planning, monitoring and assurance while allowing requirements to reflect the characteristics and risks of each asset.

How dss* supports operational readiness

dss* supports owner teams from early project development through start-up, ramp-up and stabilization. This may include defining the intended culture and operating model, establishing governance and systems of work, integrating project and operating teams, and verifying that these arrangements function in practice.

Support can continue into early operations where required to help the owner interpret performance, refine routines and interfaces, strengthen leadership practices and embed the capabilities needed for sustained operation.

Depending on the project and its stage of development, dss* support may include:

- Enterprise operational-readiness frameworks and governance.
- Project-specific readiness strategies and integrated plans.
- Operating-model, organization, workforce and capability development, including role requirements and competence assessment
- Culture development, including organizational values, expected behaviours and leadership alignment
- Systems of Work design and implementation, including integrated planning, interface management, governance, decision and escalation paths, performance measures and management routines.
- Ramp-up and early-operations support to test, refine and embed these arrangements as operating experience develops.
- Capability assurance before start-up and during ramp-up, using assessments, scenario exercises, field verification and supervised performance appropriate to the risk.
- Operational-risk, critical-control and process-safety readiness.
- Maintenance and reliability readiness.
- Contractor requirements and readiness assurance.
- Reviews before commissioning and start-up.
- Ramp-up, stabilization and transfer into routine operation.



Assessing readiness before the available options narrow

Operational readiness provides the connection between capital project delivery and sustainable operation. It should provide the owner with evidence that the asset, systems of work, controls, the intended culture and operating organization can perform under actual conditions during start-up and ramp-up. Completion of readiness activities alone is not sufficient.

Operational-readiness gaps become more difficult and expensive to resolve as commissioning and start-up approach. Owners benefit from understanding early whether the current readiness organization, scope, plans and assurance arrangements are sufficient for the asset and operating model.

dss⁺ supports mining and metals owners in establishing readiness frameworks, developing project-specific plans and reviewing whether the asset and operating organization are prepared at key project and start-up decisions.

For projects already in execution, a focused readiness diagnostic can identify material gaps, clarify accountabilities and determine which issues require action before commissioning, start-up or production.



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About dss⁺

dss⁺ is the operational transformation partner for complex and high-hazard industries. Driven by our purpose, we help organisations achieve breakthroughs in safety, performance and sustainability that build business endurance and ensure long-term success. We engage deeply within organisations to empower teams to shift mindsets, shape cultures, and establish the capabilities required at every level. We combine technical expertise and operational experience with a people-centred approach and data-driven insights. Additional information is available at www.consultdss.com.



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