AURUS MINING

Resource Development Outlook 2026

The decisions connecting minerals, infrastructure, capital and licence

WP21 | ADVISE

MINING | INFRASTRUCTURE | ENGINEERING | ENVIRONMENT

OUR POSITION

Edition 1 (vintage: USGS MCS 2026, World Bank CMO April 2026, WSA SRO Oct 2025, IEA STEPS as captured 2026-07-10) sets out a decision frame that treats mineral systems, corridors, processing, capital discipline, and environmental and social standards as one connected delivery problem. The outlook does not add Aurus forecasts; it compiles attributed scenarios

EVIDENCE FIRST | DECISIONS MADE EXPLICIT | DELIVERY CONDITIONS STATED

Contents

Executive summary

The 2026 decision frame has to hold two signals at once. On the cyclical side, World Bank Commodity Markets Outlook April 2026 shows softer trajectories in several bulk and base metals, including iron ore at $97.0/dmt in 2026f and $95.0/dmt in 2027f and zinc easing after a 2026f rise. On the structural side, the IEA Global Critical Minerals Outlook 2025 records energy sector demand as 85% of total critical minerals demand growth and describes investment growth that slowed to 5% in 2024 with exploration plateauing. The workable response is not a single view on price, but an explicit choice on what is gated by scenario, what is gated by definition, and what is gated by standards conformance.

Sources: WP21-02, WP21-07, WP21-14, WP21-17

Demand signals remain corridor and product specific. The World Steel Association Short Range Outlook October 2025 projects finished-steel demand at 1,773 Mt in 2026f with China contracting while developing economies ex-China grow, with India around 9% per year. UNCTAD Review of Maritime Transport 2025 describes seaborne iron ore volumes and ton-miles rising in 2024, and medium term maritime trade growth around 2% per year. For projects, the implication is not that volumes always rise, but that logistics, product quality, and destination mix decide cash cost exposure. Bulk systems need a freight and capacity plan that is treated as a mine planning input, not an afterthought.

Sources: WP21-09, WP21-10, WP21-11

The delivery constraint is increasingly definition and execution rather than conceptual design. AACE estimate classification ties accuracy ranges to the level of project definition and maps mining study stages to estimate classes, with discipline required before FID. Empirical evidence from 63 mining and smelting projects found as-built capital costs averaged about 14% above the bankable-feasibility estimate, with roughly half outside ±15% and large overruns occurring. In parallel, ICMM safety reporting shows fatalities rising in 2024 while TRIFR improved, and attributes most fatalities to failures to implement effective critical controls in the operating environment. Across capital and safety, the decision is whether to invest in definition and implementation capacity early enough to change outcomes.

Sources: WP21-28, WP21-29, WP21-30, WP21-45

Licence, standards, and corridor institutions now set the effective project schedule. IFC Performance Standards and the World Bank ESF are structured, dated frameworks that lenders and governments apply, while EP4 introduces climate risk assessment triggers and Scope 1 plus 2 screening for projects above 100,000 t CO2e per year. National regimes in Central Africa mandate ESIA, consultation, and certification before works, creating structural dual compliance. Corridors also depend on soft infrastructure, including customs and concession transparency, as OECD frames it. Tailings is now a defined conformance agenda under GISTM, with ICMM deadlines and a dedicated institute established in 2025 to oversee assurance. The 2026 agenda is therefore integrated: design the mineral, corridor, and standards path as one sequence of gates.

Sources: WP21-35, WP21-37, WP21-38, WP21-40

At a glance

Six evidence markers establish the scale, threshold or decision condition carried into the chapters that follow.

1,773 Mt

FINISHED-STEEL DEMAND 2026F (WSA SRO OCT 2025)

Source: WP21-09

$97.0/dmt

IRON ORE (62% FE CFR CHINA) FORECAST 2026F (WORLD BANK CMO APR 2026)

Source: WP21-02

$12,000/mt

COPPER FORECAST 2026F (WORLD BANK CMO APR 2026)

Source: WP21-03

$4,700/toz

GOLD FORECAST 2026F (WORLD BANK CMO APR 2026)

Source: WP21-04

86%

TOP-3 REFINING CONCENTRATION (CRITICAL MINERALS) IN 2024 (IEA GCMO 2025)

Source: WP21-16

1,300 km

LOBITO CORRIDOR RAIL LENGTH (OECD 2025)

Source: WP21-23

Method and boundaries

This paper is a bounded synthesis of registered public evidence. Source identifiers remain visible so that each quantitative or framework statement can be traced to its dossier row.

INTENDED READERS

- Mining and metals executives
- Project directors and delivery leaders
- Investors and lenders (project finance and corporate) and their advisors and engineers of record (without implying any Aurus role)

READING METHOD

- Read each chapter opener as a decision frame.
- Use the three section exhibits as working review instruments.
- Return to the evidence ledger before reusing any number or requirement.

BOUNDARIES

- Edition 1 vintage lock: prices and forecasts use World Bank CMO April 2026 and USGS MCS 2026; steel demand uses WSA SRO Oct 2025; critical minerals uses IEA Global Critical Minerals Outlook 2025 captured 2026-07-10. Re-verify before later editions if new vintages exist. [WP21-02, WP21-09, WP21-14]
- No Aurus point forecasts are produced. Long-run growth statements are attributed to IEA STEPS and remain scenario outputs, not project predictions. [WP21-18]
- Direct reduction feed specification of ≥67% Fe is a qualitative technical practice statement and is not presented as a transcribed market statistic. [WP21-13]
- Reference-class forecasting evidence is used qualitatively to motivate governance, not to insert new numerical overrun factors. [WP21-34]
- Corridor case citations (Simandou, Lobito, Benguela, TAZARA) are used as published examples only and do not imply any performance claim transferable to other projects. [WP21-21, WP21-23, WP21-27, WP21-25]

PUBLICATION DISCIPLINE

- No client identity or company-age claim is published.
- No Aurus delivery result is inferred from public guidance.
- Dated forecasts retain their institution and vintage.

01

DECISION FRAME

The 2026 decision frame

Treat 2026 as a gated year: scenarios set context, but definition, corridor institutions, and standards conformance decide what can be built and financed on schedule.

Gate

SCENARIO-GATED INVESTMENT STANCE (DO NOT BLEND FORECASTS) | WP21-49

$107.4/t

IRON ORE BENCHMARK ANNUAL MEAN JAN TO MAY 2026 (FRED PIORECRUSDM PULL 2026-07-08 | WP21-08

$109.4/dmt

IRON ORE ANNUAL AVERAGE 2024 (WORLD BANK CMO APR 2026) | WP21-02

1.1 Separate cyclical price prints from structural transition demand

The price tape entering 2026 is not uniform across commodity systems, and the decision frame has to keep that heterogeneity intact. In iron ore, USGS MCS 2026 notes world mine production around 2.6 Bt usable ore in 2025e and World Bank CMO April 2026 forecasts 62% Fe CFR China at $97.0/dmt in 2026f and $95.0/dmt in 2027f after a lower 2025 annual average. In contrast, World Bank CMO April 2026 shows gold at $3,442 per troy ounce in 2025 with a $4,700/toz forecast for 2026f and identifies precious metals as the strongest index category in the table. 2026 therefore rewards explicit scenario selection rather than blended narratives.

WP21-01, WP21-02, WP21-04

Critical minerals data adds a different, structural signal that sits beside cyclical pricing. The IEA Global Critical Minerals Outlook 2025 reports lithium demand up nearly 30% in 2024 and 6% to 8% growth for nickel, cobalt, graphite, and rare earths, with the energy sector accounting for 85% of total demand growth. At the same time, IEA records that critical minerals mining investment grew only 5% in 2024, with real growth about 2%, and that exploration plateaued. The 2026 decision frame should therefore treat transition exposure as a supply adequacy and concentration problem, more than as a price upside case, and it should document the scenario label used each time, such as STEPS for 2040 multipliers.

WP21-14, WP21-17

DECISION INSTRUMENT

Decision instrument: Two-signal register for 2026

Use this register at portfolio and project levels to keep cyclical pricing and structural demand signals separate and auditable by vintage.

TEST	EVIDENCE READING	DECISION RESPONSE
Price signal (cyclical)	World Bank CMO Apr 2026 and USGS MCS 2026 show softer paths for some bulks and base metals, while gold forecasts rise strongly for 2026f.	Pick a base-case price vintage and document it. Do not average across vintages. Stress test only using cited forecast sets.
Demand signal (structural)	IEA GCMO 2025 records strong energy-driven demand growth and slower investment with exploration plateaued.	Treat supply adequacy and concentration as constraints. Choose whether the project competes on cost, quality, or processing position under STEPS-labelled demand growth.
Execution signal	Empirical mining project and safety evidence points to implementation and definition as recurring failure modes.	Decide early whether to fund definition and implementation capability as primary risk controls, and define non-negotiable gates before FID.
Corridor signal	OECD frames corridors as hard infrastructure plus institutions plus services, with customs and concession terms as recurring risks.	Require a corridor plan that includes soft-infrastructure commitments and governance, more than rail and port scope.

Sources: WP21-49, WP21-02, WP21-04, WP21-14, WP21-17

1.2 Anchor demand context in dated steel and trade outlooks

Steel demand remains one of the most consequential context variables for bulk commodities and for power and emissions discussions, but it needs to be treated as a dated outlook. The World Steel Association Short Range Outlook October 2025 projects global finished-steel demand around 1,750 Mt in 2025 and 1,773 Mt in 2026f, with China down 2.0% in 2025 and down 1.0% in 2026f, while developing economies ex-China grow 4.7% in 2026f. WSA also highlights India growing near 9% per year and Africa around 41 Mt in 2025. The decision implication is to treat destination and product mix as central and to make steel exposure explicit in investment committee papers.

WP21-09, WP21-10

Trade and logistics set the realized competitiveness of mineral systems and should be embedded in the decision frame as a boundary condition. UNCTAD Review of Maritime Transport 2025 reports world maritime trade at 12,720 Mt in 2024, up 2.2%, with iron ore seaborne trade up 3.5% in tons and up 6.4% in ton-miles. UNCTAD also forecasts maritime volume growth of 0.5% in 2025f and around 2% per year in the medium term from 2026 to 2030. This mix indicates that corridor capacity, port performance, and shipment distance can change the relative position of otherwise similar mines. The decision is whether freight assumptions are treated as controllable scope or as exogenous noise.

WP21-11

DECISION INSTRUMENT

Decision instrument: Dated demand and trade assumptions sheet

A one-page standard for committees. It forces dated sourcing and clarifies what is treated as exogenous.

TEST	EVIDENCE READING	DECISION RESPONSE
Steel demand vintage	WSA SRO Oct 2025 provides 2025 and 2026f global and regional growth rates.	Record WSA SRO Oct 2025 as the demand vintage where used. If superseded, re-baseline rather than patch.
Trade and ton-mile exposure	UNCTAD RMT 2025 reports 2024 growth and medium-term shipping growth rates.	Classify the project as ton-mile sensitive or not, and require the logistics plan to reflect that classification.
Regional growth dependence	WSA shows declining China demand with growth in India and developing economies ex-China.	Decide whether the marketing case assumes rerouting to growth markets and what corridor or port changes that implies.
Risk treatment	Maritime forecasts are context, not project guarantees.	Hold a gate that requires explicit downside cases under the same dated sources.

Sources: WP21-09, WP21-10, WP21-11

1.3 Define the cross-pillar failure mode: execution and institutions

Across the four pillars of this series, the recurring failure mode is not lack of a concept but failure to execute to the intent of the concept. In project delivery, a review of 63 international mining and smelting projects found as-built capital costs averaged about 14% higher than the bankable-feasibility estimate and that large overruns occurred. In safety, ICMM data shows 42 fatalities in 2024 across 24 member companies, with 83% of fatalities attributed to failure to implement effective critical controls and with most control failures being ineffective execution in the operating environment. In corridors, OECD frames the value of a corridor as dependent on institutions and services as well as physical infrastructure, and it names customs inefficiency and monopolistic pricing risk where concessions lack transparency. The decision frame should treat execution capability and institutional design as first-order scope.

WP21-30, WP21-42, WP21-45, WP21-26

A workable approach is to convert this cross-pillar signal into gates that are explicit and auditable. For capital, AACE defines estimate classes by the level of project definition, not by ambition, and the literature on FEL and PDRI describes definition maturity as the main lever on cost and schedule certainty before FID. For safety, ICMM's critical control management guidance provides a structured process to plan, develop, implement, and improve controls. For corridors, OECD makes soft infrastructure part of the corridor definition and lists cross-jurisdiction regulatory misalignment as a risk. The decisions are therefore linked: the same organization that treats estimate accuracy as definition-dependent can also treat safety and corridor outcomes as implementation-dependent. The paper's framing uses this linkage as a synthesis constraint, not as a claim of performance.

WP21-28, WP21-33, WP21-46, WP21-26

DECISION INSTRUMENT

Decision instrument: Cross-pillar execution gate set

A minimal set of gates aligned to evidence on definition, implementation, and institutions.

TEST	EVIDENCE READING	DECISION RESPONSE
Definition gate (capital)	AACE estimate class depends only on level of definition; mining study stages map to classes.	Do not approve scope or commitments that assume Class 3 behavior while operating at Class 4 or 5 definition.
Implementation gate (safety)	ICMM attributes most fatalities to ineffective implementation of critical controls.	Require evidence that critical controls can be executed in the operating environment before ramp-up and before major change.
Institution gate (corridors)	OECD treats customs, regulation, and concession transparency as corridor elements.	Require signed or otherwise credible soft-infrastructure commitments as a condition for corridor-dependent schedules.
Learning gate	FEL and CCM both require feedback and improvement loops.	Set a cadence for independent reviews keyed to the gates, more than to calendar milestones.

Sources: WP21-28, WP21-29, WP21-33, WP21-42, WP21-45

02

MARKETS TO MINE PLANS

Demand and qualified supply

Convert demand projections into qualified supply statements that include grade, product specification, and logistics capability.

≥67% Fe

PREFERRED DIRECT-REDUCTION FEED SPECIFICATION (TECHNICAL PRACTICE, QUALITATIVE) | WP21-13

+6.4%

IRON ORE TON-MILES GROWTH 2024 (UNCTAD RMT 2025) | WP21-11

$3,000/mt

ZINC FORECAST 2026F (WORLD BANK CMO APR 2026) | WP21-07

2.1 Translate steel outlooks into ore quality and route constraints

Steel demand growth does not directly translate into iron ore demand growth without a view on production routes and input quality. The IEA Iron and Steel Technology Roadmap 2020 describes steel as about 7% of energy sector CO2 emissions, about 8% of global final energy use, and about 75% coal based, with scrap about 30% of metallic inputs and iron ore about 70%. This composition anchors why blast furnace supply chains remain significant while transition pathways remain constrained by energy and input availability. The World Steel Association Short Range Outlook October 2025 provides the dated demand growth context, with developing economies ex-China growing faster than China and India highlighted as a high-growth market. The decision for iron ore projects is to qualify the intended product and route, more than tonnage and grade in the ground.

WP21-12, WP21-09, WP21-10

In direct reduction pathways, product specification becomes an explicit constraint rather than a preference. Published technical practice cited in this series sets preferred direct reduction feed at at least 67% Fe and notes scarcity of high grade above 67% Fe as a key constraint on gas-based DR-EAF growth. That statement is qualitative and must remain labeled as practice, not as a market statistic. In 2026 decision-making, this matters because it changes what counts as qualified supply. A resource that cannot credibly produce the required specification faces a different set of options, such as beneficiation, blending, or a focus on different markets, each with distinct corridor and power implications. The decision is whether the project case is built around a defined product specification and what evidence supports that definition.

WP21-13, WP21-12

DECISION INSTRUMENT

Decision instrument: Qualified supply test for iron ore systems

A decision test that ties demand route assumptions to product specification and enabling infrastructure.

TEST	EVIDENCE READING	DECISION RESPONSE
Route assumption	IEA steel roadmap describes route mix and energy and emissions context.	State whether the commercial case assumes BF-BOF continuity, DR-EAF growth, or a mix, and keep it consistent across documents.
Product specification	Technical practice states preferred DR feed at ≥67% Fe and identifies scarcity as a constraint.	If DR-grade is assumed, require a defensible processing path to that specification, or remove the assumption.
Scrap and ore balance context	IEA reports scrap around 30% of metallic inputs and iron ore around 70%.	Use this split as a boundary condition when narrating demand. Do not imply scrap can substitute without route and energy evidence.
Market vintage	WSA SRO Oct 2025 provides dated demand projection structure.	Record the demand vintage and define a trigger for re-validation if a new SRO changes regional growth assumptions.

Sources: WP21-12, WP21-13, WP21-09

2.2 Base metals: treat 2026 to 2027 forecasts as a scenario set, not a promise

For base metals, this outlook uses only the World Bank CMO April 2026 forecast set and USGS MCS 2026 production context and treats both as dated. Copper illustrates the need to avoid selective anchoring: USGS MCS 2026 reports around 23 Mt mined and around 29 Mt refined copper in 2025, while World Bank CMO shows an annual price of $9,947/mt in 2025 and forecasts $12,000/mt in 2026f and $11,000/mt in 2027f. Those values can support scenario testing, but they do not resolve project viability without cost, corridor, and permitting evidence. The decision is to define a base-case vintage and preserve the downside and upside cases inside the same publication set to avoid hidden optimism.

WP21-03

Nickel and zinc show how balance conditions can sit behind price prints and why qualified supply needs more than a resource statement. USGS MCS 2026 indicates nickel mine production at 3.9 Mt in 2025e, with Indonesia around two-thirds and a surplus each year since 2022, including 182 kt in 2024, while World Bank CMO forecasts nickel at $17,000/mt in 2026f and $17,500/mt in 2027f. For zinc, USGS MCS 2026 shows 13.0 Mt in 2025e with an 85 kt refined surplus in 2025, and World Bank CMO forecasts $3,000/mt in 2026f then $2,750/mt in 2027f. The decision is to qualify supply by position on the cost curve and by ability to deliver product to market, not by exposure to a single-year forecast.

WP21-06, WP21-07

DECISION INSTRUMENT

Decision instrument: Scenario integrity check for CMO Apr 2026 forecasts

A consistency tool to stop committees from mixing out-of-date prices, selective years, or single-commodity optimism.

TEST	EVIDENCE READING	DECISION RESPONSE
Forecast vintage lock	World Bank CMO Apr 2026 provides 2026f and 2027f trajectories for several commodities.	Adopt one forecast vintage for a decision package. If another vintage is used, re-base all commodities and explain the change.
Balance and surplus context	USGS MCS 2026 notes nickel surplus conditions and zinc refined surplus in 2025.	Where surplus is documented, require sensitivity cases that assume price weakness persists even if the point forecast rises.
Production and refining context	USGS provides mined and refined volumes for copper.	Use production context to test whether the project narrative relies on implied supply gaps that are not evidenced.
Presentation rule	Forecasts are attributed and dated; Aurus does not generate point forecasts.	Prevent charts or tables that present CMO figures as internal projections.

Sources: WP21-03, WP21-06, WP21-07

2.3 Critical minerals demand growth meets concentration exposure

The IEA Global Critical Minerals Outlook 2025 stresses that demand growth is being driven by the energy sector and that this growth is not evenly supported by supply-side investment. It records lithium demand rising nearly 30% in 2024 and that nickel, cobalt, graphite, and rare earths grew 6% to 8%, with the energy sector accounting for 85% of total demand growth. At the same time, it records that mining investment grew only 5% in 2024 with real growth around 2% and that exploration plateaued. For 2026 decisions, this combination changes what qualifies as supply. A project that relies on a tight market should still pass a definition and delivery gate, because the supply response risk can also manifest as cost inflation and schedule slip rather than only as higher prices. The decision is to define the demand driver and the supply response assumption explicitly and label it to IEA's dated publication.

WP21-14, WP21-17

Concentration exposure needs to be treated as a core supply qualification parameter, not a geopolitical footnote. The IEA Global Critical Minerals Outlook 2025 reports that the top three nations' refining market share rose from around 82% in 2020 to 86% in 2024 and that the top three mining share rose from 73% to 77% over the same period. It also projects that average top three refining concentration declines only marginally to 82% by 2035. In parallel, IEA notes a steep price reversal for lithium, with prices down over 80% since 2023, and declines of 10% to 20% for graphite, cobalt, and nickel prices in 2024. The decision is to test whether a project's commercial logic depends on concentration easing quickly or on price recovery, and to treat both as uncertain within a dated source set.

WP21-16, WP21-15

DECISION INSTRUMENT

Decision instrument: Concentration and price-volatility qualifier (critical minerals)

A project-level qualifier that is separate from resource size and grade. It addresses refining concentration, investment pace, and recent volatility.

TEST	EVIDENCE READING	DECISION RESPONSE
Concentration qualifier	IEA reports top-3 refining share 86% in 2024 and projects 82% by 2035.	If the project depends on diversified refining, require a documented offtake and processing pathway that does not assume rapid deconcentration.
Investment and exploration qualifier	IEA reports mining investment growth slowed to 5% in 2024 and exploration plateaued.	If the thesis assumes supply tightness, do not use it to waive definition or permitting gates. Treat it as a scenario input only.
Volatility qualifier	IEA reports lithium prices down over 80% since 2023 and 10% to 20% price drops for other minerals in 2024.	Require downside pricing cases within the same IEA vintage where volatility is highlighted, and test liquidity and covenant resilience.
Scenario labeling	IEA includes STEPS-based long-term multipliers elsewhere in the same outlook family.	When long-term demand growth is cited, label the scenario each time and avoid mixing STEPS with other scenario constructs.

Sources: WP21-16, WP21-17, WP21-15

03

FROM GROUND TO SANCTION

Exploration and project pipelines

Stop treating pipeline volume as deliverable. In 2026, investment and exploration data, disclosure codes, and corridor dependencies decide which projects can mature into reserves and financeable designs.

+5%

CRITICAL-MINERALS MINING INVESTMENT GROWTH IN 2024 (REAL ~2%) | WP21-17

Trace

RESOURCE TO RESERVE TRACEABILITY VIA CRIRSCO ARCHITECTURE | WP21-31

2021

SEC SK-1300 COMPLIANCE START (FY BEGINNING ON OR AFTER 1 JAN 2021) | WP21-32

3.1 Pipeline reality check: growth in demand does not equal growth in mature projects

The IEA Global Critical Minerals Outlook 2025 provides a direct warning that pipeline narratives can outpace real project maturation. It reports that mining investment rose just 5% in 2024, down from 14% in 2023, with real growth around 2%, and it states that exploration plateaued in 2024. Those statements matter because many transition-linked demand cases assume rapid new supply, but investment and exploration are leading indicators for the conversion of concepts into studies and reserves. When a committee hears that copper demand rises 30% by 2040 under STEPS and that announced supply is materially below demand by 2035, the correct response is not to assume any one project becomes necessary. The correct response is to tighten gates on definition, permitting, and delivery so that only qualified projects advance.

WP21-17, WP21-18

Longer-term demand multipliers are still relevant when they are labeled and bounded. The IEA Global Critical Minerals Outlook 2025 states under STEPS that copper demand rises 30% by 2040 and that lithium demand is five times by 2040 with graphite and nickel doubling, while announced supply is about 30% below 2035 demand for copper. These are scenario outputs, not a claim of inevitability. They provide a basis to test whether a pipeline is aligned to a plausible scale of demand, and to test whether processing capacity, corridors, and standards can keep pace. The decision is to use STEPS as a stress-case lens for bottlenecks and concentration exposure while still requiring each project to clear resource definition and execution gates. The scenario label has to appear with every reference to the multipliers and the 2035 supply gap statement.

WP21-18

DECISION INSTRUMENT

Decision instrument: Pipeline gating under STEPS-labelled growth

A gate sequence that treats STEPS outputs as context while protecting against premature sanction of immature concepts.

TEST	EVIDENCE READING	DECISION RESPONSE
Scenario gate	IEA STEPS provides long-run multipliers and a copper supply gap statement.	Use STEPS only as a context scenario. Do not translate it into a project schedule or sanction target without independent project evidence.
Investment reality gate	IEA reports slowed mining investment growth and exploration plateau.	Assume pipeline maturation is constrained. Prioritize projects with credible definition work programs over large lists of early-stage concepts.
Concentration gate	IEA reports high refining concentration persists to 2035 projection.	If the project depends on new processing capacity, require explicit commitments and a delivery plan. Do not assume market-led diversification.
Quality of inputs gate	Where processing or product specs are tight, the project must show a qualified route to spec.	Advance only if the intended product specification is demonstrated as achievable at study level and aligned to the chosen scenario.

Sources: WP21-18, WP21-17, WP21-16

3.2 Disclosure codes: treat resource classification as a decision tool, more than compliance

Resource and reserve disclosure standards are not administrative overhead in 2026. They are decision tools that define what can be called a resource, what can be called a reserve, and what study stages can responsibly claim. The CRIRSCO family, including JORC 2012, SAMREC 2016, PERC 2021, and CIM Definition Standards incorporated by NI 43-101, shares a common architecture from Exploration Results through Mineral Resources to Ore Reserves, gated by a Competent or Qualified Person. The practical implication is that pipeline statements should distinguish between Inferred Resources and Probable or Proved Reserves, because those categories carry different confidence and different obligations in design and permitting. The decision is to require that every investment memo and corridor discussion specifies the resource class used and whether modifying factors are evidenced to reserve level, rather than implying bankability from early-stage exploration results.

WP21-31

In the United States context, the SEC's subpart 1300 of Regulation S-K has aligned disclosure architecture with CRIRSCO-style resource and reserve reporting for the first time, with adoption in 2018 and compliance for fiscal years beginning on or after 1 January 2021. That dating matters because it affects how multi-jurisdiction portfolios present their pipeline and how comparability is achieved across markets. The decision is to use the aligned architecture to improve internal comparability and to stop mixed-category pipeline aggregation that hides uncertainty. For delivery planning, the link to estimating is direct: AACE mining guidance maps Class 5 estimates to PEA on Inferred Resources and Class 3 to feasibility on Probable or Proven reserves. A portfolio that treats Inferred-only assets as if they support Class 3 capital commitments is internally inconsistent. The committee should require a statement of alignment between disclosure category, study class, and estimate class at each gate.

WP21-32, WP21-31, WP21-29

DECISION INSTRUMENT

Decision instrument: Resource category to study and estimate alignment check

A consistency check that links disclosure architecture to study maturity and estimate class expectations.

TEST	EVIDENCE READING	DECISION RESPONSE
Resource architecture	CRIRSCO family defines Exploration Results, Resources, and Reserves with QP or CP gating.	Require the project to state its current category and the evidence plan to convert to the next category before major commitments.
US disclosure comparability	SEC SK-1300 aligns to CRIRSCO-style architecture with compliance starting FY on or after 1 Jan 2021.	If reporting spans jurisdictions, specify the reporting basis used and reconcile category terms to a single internal decision language.
Study to estimate mapping	AACE mining guidance maps PEA on Inferred to Class 5 and feasibility on reserves to Class 3.	Do not authorize Class 3 level commitments unless reserve basis and feasibility definition are demonstrated.
Committee artifact	Inconsistent category and estimate language is a governance risk.	Adopt a standard table in every memo showing category, study stage, estimate class, and the next gate.

Sources: WP21-31, WP21-32, WP21-29

3.3 Corridor dependency: pipelines mature only where enabling systems are credible

A pipeline is only as real as the enabling systems that allow development and shipment. OECD's corridor framework defines a corridor as hard infrastructure plus institutions and services, and it identifies risks such as customs inefficiency across jurisdictions, regulatory misalignment, and monopolistic pricing risk in the absence of transparent concessions. These are not abstract risks. They decide whether a corridor-dependent deposit can mature from a resource statement into a sanctioned project with an executable schedule. The committee decision is to classify each pipeline asset as corridor-independent, corridor-dependent with credible institutional path, or corridor-dependent with unresolved institutional constraints. That classification then drives what definition work is justified and what should be deferred until corridor governance and concession terms become clearer. It also helps keep exploration spending aligned to deliverability rather than to geological attractiveness alone.

WP21-26

The OECD Lobito Corridor background note provides an example of a corridor positioned to support critical minerals movements, including rail length and investment commitments, and it cites DRC's cobalt dominance and copper output in the region. These facts show why corridor conversations converge on minerals supply chains. However, the paper's decision stance is that corridor news does not replace project definition or licence work. A corridor can improve transport economics and shift market access, but it also introduces multi-jurisdiction permitting, concession, and customs dependencies that need to be actively managed. The decision is to treat corridor agreements and soft infrastructure arrangements as gating deliverables, similar to resource conversion gates, rather than as external background that will resolve itself. For high-consequence corridors, cumulative impact assessment guidance also becomes relevant at the corridor scale as described by IFC's six-step process in its 2013 handbook.

WP21-23, WP21-26, WP21-19, WP21-41

DECISION INSTRUMENT

Decision instrument: Corridor dependency classification for project pipelines

A structured way to connect pipeline prioritization to corridor institutions, more than to geology or price outlooks.

TEST	EVIDENCE READING	DECISION RESPONSE
Dependency class	OECD defines corridors as hard infrastructure plus institutions plus services.	Classify each asset as independent, dependent with credible path, or dependent with unresolved constraints. Use the class to prioritize spending.
Institutional risk screen	OECD names customs inefficiency, regulatory misalignment, and monopoly pricing risk absent transparent concessions.	For dependent assets, require a plan and evidence for customs, concession transparency, and cross-border alignment before major study spend.
Regional supply chain relevance	OECD notes corridor positioning alongside DRC cobalt and copper context.	State the intended supply chain and whether the corridor is necessary or optional to that chain.
Cumulative effects	IFC CIA handbook provides a six-step process for corridor-scale cumulative impacts.	If multiple projects share the corridor, require a cumulative impacts approach early to reduce later schedule shocks.

Sources: WP21-26, WP21-23, WP21-19, WP21-41

04

CONVERSION CONSTRAINTS

Processing and power

Processing position and power requirements shape competitiveness. In 2026, refining concentration, steel route energy intensity, and product specifications create hard constraints that need early decision-making.

86%

TOP-3 REFINING SHARE IN 2024 (CRITICAL MINERALS) | WP21-16

~75%

STEEL ENERGY FROM COAL (IEA STEEL ROADMAP) | WP21-12

Scope

EP4 CLIMATE RISK AND EMISSIONS SCREENING SCOPE TRIGGER | WP21-37

4.1 Processing concentration is a supply risk and a permitting risk

Processing and refining are no longer neutral steps between mining and end use. The IEA Global Critical Minerals Outlook 2025 quantifies a continuing rise in concentration, with the top three nations' refining market share increasing from around 82% in 2020 to 86% in 2024 and only marginally declining to 82% by 2035 in its projection. That concentration profile creates supply chain exposure for projects that plan to sell intermediates into a limited set of refining destinations. It also creates a decision point on where new processing capacity should sit and what power and permitting requirements it triggers. The project-level decision is to explicitly choose a processing pathway and state whether the path increases or reduces exposure to concentrated refining capacity. Where a project implies future deconcentration, it must be treated as a scenario assumption, not as a plan.

WP21-16

Price volatility and investment pace complicate processing decisions because they can compress margins while commitments are made. IEA reports lithium prices down over 80% since 2023 and 10% to 20% price drops in 2024 for graphite, cobalt, and nickel, while also recording slowed investment growth and exploration plateauing. This is the combination that can strand a processing build-out if it is justified by peak-cycle margins or by assumed supply tightness. For committees, the decision is to separate the strategic reason for processing, such as security of supply, quality control, or market access, from the cyclical justification. That separation then informs whether processing should be staged, whether it should be built with modularity, and what offtake or financing structures are required before committing to long-lead items. The paper does not prescribe a build decision; it provides a gating logic tied to the dated evidence.

WP21-15, WP21-17

DECISION INSTRUMENT

Decision instrument: Processing pathway qualifier under concentration and volatility

A qualifier that forces explicit choices about processing geography, exposure, and sequencing.

TEST	EVIDENCE READING	DECISION RESPONSE
Concentration exposure	IEA reports 86% top-3 refining share in 2024 and a modest decline projected by 2035.	If selling into concentrated refining, require counterparty risk controls. If aiming to diversify, require credible financing and permitting paths.
Volatility exposure	IEA reports steep post-2023 lithium price decline and broad 2024 price drops in several minerals.	Test processing economics under the adverse price period described by IEA, more than under a recovery case.
Investment pace signal	IEA reports investment growth slowed and exploration plateaued in 2024.	Avoid assuming that third-party processing capacity will arrive on time. Treat external capacity as uncertain unless contracted.
Stage decision	Processing builds are long lead and permitting intensive.	Choose a staged or single-step approach and tie it to explicit gates on offtake, permits, and power arrangements.

Sources: WP21-16, WP21-15, WP21-17

4.2 Power and emissions: treat steel and lender standards as design constraints

Power requirements and emissions are not side calculations for 2026, because standards and financing triggers can convert them into schedule and scope. The IEA steel roadmap frames the scale: steel accounts for about 8% of global final energy and about 7% of energy-sector CO2 emissions, with about 75% of its energy from coal and iron ore about 70% of metallic inputs. Those facts shape the direction of travel in processing and in value chain claims. In parallel, EP4 requires climate change risk assessment for Category A projects and for all projects where Scope 1 plus 2 exceed 100,000 t CO2e per year. The decision is to treat emissions quantification and power sourcing as front-end design inputs, because they can affect lender categorization and the required assessment work program. Teams should avoid treating climate assessment as a late compliance task; it is a gating deliverable where EP4 applies.

WP21-12, WP21-37

Standards alignment also affects how cumulative effects are handled for processing hubs and corridor-linked industrial areas. IFC Performance Standards and the World Bank ESF are both structured frameworks with defined effective dates, and they are commonly applied in parallel with national ESIA requirements. IFC's cumulative impact assessment handbook provides a six-step process that is relevant when multiple facilities share a power system, water source, or corridor. For decisions in 2026, this means processing and power plans should include a boundary definition for cumulative impacts and a plan for stakeholder engagement, rather than assuming single-project impacts can be assessed in isolation. The decision is to choose the assessment framework early, define the project and area of influence consistently, and keep the evidence trail clear so that design changes do not trigger late rework across multiple standards regimes.

WP21-35, WP21-41, WP21-38

DECISION INSTRUMENT

Decision instrument: Power and emissions gate for processing options

A gate that links power design choices to lender standards triggers and cumulative impacts planning.

TEST	EVIDENCE READING	DECISION RESPONSE
Emissions screening	EP4 requires climate risk assessment for projects where Scope 1 plus 2 exceed 100,000 t CO2e per year and for Category A projects.	Decide whether the project is likely to cross the EP4 screening trigger and plan assessment scope accordingly.
Energy intensity context	IEA reports steel energy and emissions shares and coal dependence.	If the project narrative includes decarbonized processing, require an energy balance and a power sourcing plan consistent with that claim.
Framework selection	IFC has 8 Performance Standards; World Bank ESF has 10 ESS with defined effective dates.	Select the framework set that applies and map deliverables to the project schedule at FEL stages.
Cumulative impacts boundary	IFC CIA handbook sets out a six-step process for corridor-scale cumulative effects.	Where hubs or corridors exist, define the area of influence and cumulative effects approach early to reduce late-stage surprises.

Sources: WP21-37, WP21-12, WP21-35, WP21-41

4.3 Product specification decisions: direct reduction feed and metallurgical coal dependencies

In bulk supply chains, processing decisions often reduce to product specification and the downstream route. Technical practice referenced in this series states preferred direct reduction feed at at least 67% Fe and notes scarcity of high-grade above 67% Fe as a key constraint. That statement is qualitative and should be treated as practice, not as a market statistic. The implication is that an orebody's inherent grade and its beneficiation response can decide whether it can credibly target DR feed markets. In parallel, USGS MCS 2026 notes that metallurgical coal was added to the US Final 2025 Critical Minerals List for its role in BF-BOF steelmaking. This listing shows that even a transition narrative retains dependencies on established inputs. The decision is therefore to state which route is assumed, what inputs are critical to it, and what processing investments are required to meet the intended specification.

WP21-13, WP21-20

These specification decisions connect directly to corridor and power planning. A project that requires beneficiation to reach DR-grade, or that plans to ship a particular concentrate or pellet product, will have different rail, port, and storage requirements and may have different community impacts due to plant siting and power draw. OECD's corridor framework reminds decision-makers that services and institutions are part of corridor performance, more than rail steel, while UNCTAD's trade statistics show how ton-mile growth can amplify logistics exposure. The decision is to integrate product specification with corridor capability at study stage, and to avoid "ore first, infrastructure later" sequencing. Where corridor capacity expansion is assumed, the project case should include evidence of institutional and concession readiness, more than of engineering feasibility. This is a framing requirement; it does not assume any particular corridor outcome beyond what is in the cited sources.

WP21-26, WP21-11, WP21-13

DECISION INSTRUMENT

Decision instrument: Product specification to enabling systems map

A map that forces explicit links between intended product, processing scope, corridor needs, and standards triggers.

TEST	EVIDENCE READING	DECISION RESPONSE
Target product and route	Technical practice sets DR feed preference at ≥67% Fe; USGS lists metallurgical coal as critical for BF-BOF role.	Declare the downstream route and target product. List the critical inputs and constraints, and show how they are managed.
Processing scope implication	Meeting tighter specifications can require additional beneficiation or processing capacity.	If additional processing is needed, stage it and gate it with offtake, power, and permitting readiness.
Corridor capability implication	OECD corridor definition includes institutions and services; UNCTAD shows trade and ton-mile dynamics.	Specify corridor services needed and identify institutional dependencies that must be resolved for shipment readiness.
Assurance and disclosure	Claims about route and product affect commercial and permitting narratives.	Require internal consistency across disclosure, study reports, and lender documentation.

Sources: WP21-13, WP21-20, WP21-26, WP21-11

05

DELIVERY DISCIPLINE

Corridors and logistics

Corridors decide which resources become operating mines. In 2026, the decision problem is to convert corridor announcements into executable capacity with governance, concessions, and cumulative impact management.

1,300 km
LOBITO CORRIDOR RAIL LENGTH (PORT OF LOBITO TO LUAU) | WP21-23

600+ km
NEW MULTI-USE TRANS-GUINEAN RAIL (SIMANDOU SYSTEM) | WP21-22

12,720 Mt
WORLD MARITIME TRADE 2024 (UNCTAD RMT 2025) | WP21-11

5.1 Hard infrastructure is necessary but not sufficient

OECD's corridor framework is explicit that a corridor is more than track and port. It defines a corridor as hard infrastructure plus institutions, sometimes called soft infrastructure, plus services. OECD names corridor risks that recur across jurisdictions, including customs inefficiency across borders, regulatory misalignment, landmine-legacy contamination, and monopolistic pricing risk where concessions lack transparency. The 2026 decision implication is that a corridor-dependent mining project should not treat rail and port as externalities. It should carry an institution and services workstream with deliverables that are as real as a bridge count. This is a governance decision: either the project owns the interface risk through explicit agreements and management capacity, or it accepts schedule and cost uncertainty as a probability. Committees should require corridor risk registers that distinguish what can be influenced from what is purely external.

WP21-26

UNCTAD's shipping statistics show why these institutional factors matter economically. UNCTAD Review of Maritime Transport 2025 reports 12,720 Mt of world maritime trade in 2024 and notes that iron ore seaborne trade increased more than in tons but more sharply in ton-miles. When ton-miles rise, reliability and transit time variability increase working capital needs and can increase demurrage exposure. For a corridor, soft infrastructure such as customs performance and concession transparency can directly affect dwell times and throughput utilization, even if headline capacity is high. The decision is therefore to test corridor economics under service-level assumptions, more than under engineered nameplate capacity. In 2026, the right question is often whether the corridor can operate at a stable service level across jurisdictions, and what evidence exists for that stability.

WP21-11, WP21-26

DECISION INSTRUMENT

Decision instrument: Corridor readiness gate (hard, institution, service)

A corridor readiness gate that is compatible with OECD's definition and can be used in project stage-gates.

TEST	EVIDENCE READING	DECISION RESPONSE
Hard infrastructure status	Corridor scope includes rail, port, and related assets.	Confirm physical scope, interface points, and commissioning sequence before locking mine ramp-up assumptions.
Institutional readiness	OECD highlights customs inefficiency and regulatory misalignment as named risks.	Require evidence of cross-border process alignment and customs performance commitments before FID for corridor-dependent projects.
Concession and pricing governance	OECD notes monopolistic pricing risk without transparent concessions.	Treat concession terms as a bankability input. Require transparency and enforceable service terms where possible.
Service-level testing	UNCTAD shows rising ton-miles and medium-term trade growth context.	Run logistics cases on service assumptions such as dwell times and reliability, more than on volume growth assumptions.

Sources: WP21-26, WP21-11

5.2 Case citations: Simandou system scope illustrates integrated corridor build-out

Simandou is a useful market-citation example because published sources describe a mine plus corridor system with specified capacity and engineering attributes. Rio Tinto reporting cites combined system capacity up to 120 Mtpa, a SimFer mine design at about 60 million dry tonnes per year with a 30-month ramp-up, and a dated logistics milestone with first ore railed in November 2025 and first shipment in December 2025. Rio Tinto also reports SimFer ore reserves of around 1.5 Bt with stated grades for proved and probable categories. These figures are not used here to infer outcomes or to generalize performance. They are used to illustrate the decision reality that a deposit becomes a shipping operation only when mine, rail, and port schedules are integrated and when the corridor is built to an operating standard that suits heavy haul logistics. The decision lesson is to structure project governance so that corridor and mine are one system through commissioning and ramp-up.

WP21-21

The published engineering detail for the trans-Guinean rail component highlights why interface risk dominates. Sources cited in the dossier describe more than 600 km of new multi-use rail, double-track design, 12 stations, 206 bridges totaling 79.2 km, and four tunnels totaling 27.6 km, with 1,435 mm standard gauge heavy-haul design. These attributes show that corridor scope is multidimensional, with civil, track, structures, and operations requirements that must align with mine production and stockpile design. The decision implication is that even where a corridor is built, throughput depends on operational rules, maintenance regimes, and service prioritization, which sit in the soft infrastructure and services domain identified by OECD. In project controls, the corridor should be treated as a set of critical-path interfaces rather than as a single schedule bar. Where multiple users exist, the committee should insist on transparent allocation rules and performance reporting mechanisms.

WP21-22, WP21-26

DECISION INSTRUMENT

Decision instrument: Mine-corridor interface register (heavy haul systems)

A register to identify and manage the interfaces that decide whether nameplate capacity can be realized in ramp-up.

TEST	EVIDENCE READING	DECISION RESPONSE
System capacity claim	Published sources cite system capacity and ramp-up timelines for a cited integrated system.	Where a capacity claim is used in planning, require a matching commissioning and ramp-up plan across mine, rail, and port.
Engineering interface density	Published sources list bridges, tunnels, and stations as part of corridor scope.	Treat interface points as critical path. Assign owners for each interface and hold readiness reviews before handover.
Operations and allocation rules	OECD corridor framework identifies services and governance as part of corridor performance.	Define operating rules, maintenance access, and allocation priority. Require transparent mechanisms where third parties share capacity.
Evidence discipline	Case citations are illustrative and dated, not transferable performance claims.	Use case data only to frame questions and gates. Do not cite it as evidence of cost, schedule, or success likelihood elsewhere.

Sources: WP21-21, WP21-22, WP21-26

5.3 Lobito and regional rehabilitation: corridor economics depends on financing, concessions, and rehab

The OECD Lobito Corridor background note offers a corridor example where rail rehabilitation, concession structure, and multilateral backing are part of the value proposition. It describes the Lobito Corridor as a 1,300 km rail line from the Port of Lobito to Luau at the DRC border and reports multilateral backing exceeding US$10 billion and a 30-year concession signed in 2023. OECD also reports committed investment of US$455 million in Angola and US$100 million in DRC. Separately, cited releases report that LAR secured US$753 million in development financing from the US DFC and DBSA and that expected impacts include increased transport capacity to 4.6 Mt and transport cost reduction up to 30%. These claims are attributable to the cited institutions and should be treated as such. The decision implication is that corridor economics extends beyond an engineering question; it is a finance and concession question that can change capacity, pricing, and access terms for mining projects that rely on the corridor.

WP21-23, WP21-24

OECD also cites the history of corridor underutilization and rehabilitation as a reminder that capacity can degrade and that governance and maintenance matter. It notes that the Benguela Railway, completed in 1931, was cut to just 34 km of operation during Angola's civil conflict and then reconstructed from 2004 with full rehabilitation by 2014, with design parameters and capacity cited. It also notes that TAZARA was built in the 1970s with a US$500 million interest-free Chinese loan and is now operating at a fraction of former capacity, with a rehabilitation or concession deal under negotiation around US$1 billion. These are not presented as predictions. They frame a decision discipline: corridor-dependent projects should test initial commissioning, and long-run maintainability and concession incentives. The committee decision is to require that corridor plans include maintenance funding logic, operating performance monitoring, and contractual recourse mechanisms where possible, because corridor degradation can reverse mine competitiveness within a single investment cycle.

WP21-27, WP21-25

DECISION INSTRUMENT

Decision instrument: Corridor bankability and maintainability test

A test to separate corridor headline announcements from bankable and maintainable transport capability.

TEST	EVIDENCE READING	DECISION RESPONSE
Concession structure	OECD reports a 30-year concession for Lobito-related operations and committed investments.	Verify concession duration, access rights, and pricing governance. Treat these as bankability inputs for corridor-dependent mines.
Financing and performance claims	Cited releases report financing totals and expected impacts including capacity and cost reductions.	Treat performance impacts as attributable claims. Require independent verification plans before embedding them in mine economics.
Rehabilitation history	OECD reports conflict-related degradation and later rehabilitation for Benguela and underperformance and rehab negotiations for TAZARA.	Include a maintainability plan and funding logic. Stress test the mine plan against corridor degradation scenarios.
Soft infrastructure risks	OECD names customs inefficiency and regulatory misalignment as corridor risks.	Require a cross-border operations plan that addresses customs and regulatory processes as part of commissioning readiness.

Sources: WP21-23, WP21-24, WP21-27, WP21-25, WP21-26

06

CAPITAL DISCIPLINE

Capital and cost

In 2026, cost and schedule certainty are purchased through definition, stage-gates, and governance, not through optimism. Estimating class, FEL maturity, and empirical overrun evidence should be visible in every decision pack.

Class 5

0% TO 2% DEFINITION AND WIDE ACCURACY RANGE (AACE) | WP21-28

~14%

AVERAGE AS-BUILT CAPEX ABOVE BANKABLE FEASIBILITY (MINING AND SMELTING SAMPLE) | WP21-30

Hold

DO NOT SANCTION BEFORE DEFINITION MATURITY IS DEMONSTRATED | WP21-33

6.1 Estimating discipline: class is determined only by definition

AACE International's estimate classification is a governance tool as much as an engineering tool. It defines five classes keyed to the level of project definition, with Class 5 at 0% to 2% definition and wide accuracy ranges and Class 1 at 50% to 100% definition with narrower ranges. AACE is explicit that only the level of project definition determines the class, not the ambition of the team. In mining applications, AACE maps Class 5 roughly to a PEA on Inferred Resources, Class 4 to pre-feasibility, and Class 3 to feasibility or bankable feasibility on Probable or Proven reserves. The decision implication is that committees should not treat cost accuracy as negotiable. If the definition is Class 4, then the decision should acknowledge Class 4 uncertainty and set next gates accordingly, rather than pretending Class 3 accuracy is available. This also protects the organization against later claims that overruns were unforeseeable; AACE provides a clear language for what uncertainty was inherent at each stage.

WP21-28, WP21-29

Empirical overrun evidence shows why this discipline matters even when the study quality is high. A review of 63 international mining and smelting projects found that as-built capital costs averaged about 14% higher than the bankable-feasibility estimate, with roughly half outside ±15%, and that very large overruns occurred in about one project in thirteen. This evidence does not claim that any given project will overrun by that amount; it describes a distribution observed in a sample. The decision implication is to treat "bankable" as an estimate class and documentation standard, not as a guarantee. Committees should therefore require explicit contingency philosophy and reference-class thinking for schedule and cost risk, and they should maintain traceability between the level of definition and the accuracy claims used in financing discussions. This is where FEL maturity and PDRI scoring can be used as definition evidence in a structured way, as described by IPA and CII.

WP21-30, WP21-33

DECISION INSTRUMENT

Decision instrument: Estimate class integrity gate

A gate that prevents mismatches between estimate confidence, resource category, and commitment level.

TEST	EVIDENCE READING	DECISION RESPONSE
Definition evidence	AACE class depends only on level of project definition and provides definition percentage bands.	Require a definition pack and classify the estimate accordingly. Do not accept a lower class label without definition evidence.
Mining study mapping	AACE maps PEA on Inferred to Class 5, pre-feasibility to Class 4, and feasibility on reserves to Class 3.	Align commitments to the mapped study stage. If the project lacks reserve basis, treat it as earlier class for capital governance.
Overrun awareness	Empirical review shows average as-built higher than BFS and many outside ±15%.	Hold a risk review that treats overrun as plausible even at BFS. Require explicit contingency and schedule risk treatment.
Committee decision record	Definition maturity is the leading indicator of estimate reliability.	Record in minutes the estimate class and what would be required to advance to the next class.

Sources: WP21-28, WP21-29, WP21-30

6.2 Front-end loading: definition maturity is the primary lever before FID

Front-end loading and front-end engineering design are decision levers because they increase definition before the point of irreversible commitment. IPA's description of FEL emphasizes investment in definition before sanction as the primary lever on outturn cost and schedule certainty, and CII's PDRI overview describes how definition maturity can be assessed using structured elements. This is aligned with AACE's position that estimate class is definition-determined. For 2026 decisions, the implication is that FEL should be treated as a funded risk control, not as a discretionary overhead that is trimmed when prices soften. Where commodity prices are forecast softer, the temptation is to shorten early phases. Evidence suggests that shortening definition increases the probability of cost and schedule surprises later. The decision is to set a minimum definition maturity gate that cannot be bypassed, and to link that gate to clear deliverables such as scope freeze, constructability reviews, and contracting strategy readiness.

WP21-33, WP21-28, WP21-02

Reference-class forecasting literature also supports a disciplined approach, even when it is used qualitatively. The Flyvbjerg overrun database is cited here as an attributed empirical base used directionally: large infrastructure projects systematically show cost overrun and benefit shortfall relative to sanction estimates. This qualitative signal should not be turned into a point estimate in a project model, and this paper does not do that. It should, however, influence governance. The decision is to require an outside view and to compare the project to a reference class for cost and schedule, while keeping the primary focus on improving definition and execution capacity through FEL and PDRI. Committees should also ensure that corridor and institutional dependencies identified by OECD are part of the reference class comparison, because projects with cross-border and concession dependencies have different risk profiles than greenfield standalone builds.

WP21-34, WP21-33, WP21-26

DECISION INSTRUMENT

Decision instrument: FID readiness gate (definition and outside view)

A gate that joins definition maturity evidence to an outside-view check without generating any new numerical forecast.

TEST	EVIDENCE READING	DECISION RESPONSE
FEL maturity evidence	IPA and CII describe FEL and PDRI as methods to quantify definition maturity.	Require documented FEL stage and PDRI or equivalent definition evidence before FID.
Estimate class alignment	AACE ties estimate class to definition.	Confirm the estimate class matches the demonstrated definition level, and keep commitments consistent with that class.
Outside view (qualitative)	Flyvbjerg database supports the systematic presence of overruns and benefit shortfalls in large infrastructure.	Conduct a reference-class discussion and document the main differences and mitigations without inserting a new point overrun factor.
Corridor dependency check	OECD corridor framework names soft infrastructure risks that affect delivery.	If corridor-dependent, require that institutional readiness is included in the FID readiness pack.

Sources: WP21-33, WP21-28, WP21-34, WP21-26

6.3 Standards-driven capital: tailings conformance and assurance commitments affect scope

Capital and cost planning in 2026 has to incorporate standards conformance that did not exist in earlier project eras. The Global Industry Standard on Tailings Management launched on 5 August 2020, co-convened by ICMM, UNEP, and PRI, and it is structured into 6 topic areas, 15 Principles, and 77 auditable Requirements. It applies to existing and to-be-built tailings facilities and states a core objective of zero tolerance for human fatalities and zero harm. For committees, the decision implication is that tailings scope extends beyond a matter of engineering preference. It carries auditable requirements that can influence design basis, monitoring systems, governance, and closure provisions. This affects capital profiles and schedule, particularly where upgrades to existing facilities are needed in parallel with new development. The correct discipline is to treat tailings conformance scope as a defined work package in the cost estimate, with a clear assurance and audit plan.

WP21-39

Conformance deadlines and governance structures also affect timing risk and resourcing. ICMM member commitments specify that facilities with Extreme or Very High potential consequences were to conform by 5 August 2023 and that all other operating facilities were to conform by 5 August 2025, and the Global Tailings Management Institute was created in January 2025 to oversee the standard. These dated commitments can change how owners allocate capital between growth projects and compliance programs, and they can change lender expectations for assurance. The decision is to build a conformance roadmap that is synchronized with project stage-gates and to make explicit whether the tailings facility is new build or existing with upgrade requirements. Where the organization is not an ICMM member, the standard can still be a lender and stakeholder expectation; this paper does not assume membership. It only notes the published structure and deadlines as part of the 2026 environment in which capital decisions are made.

WP21-40, WP21-39

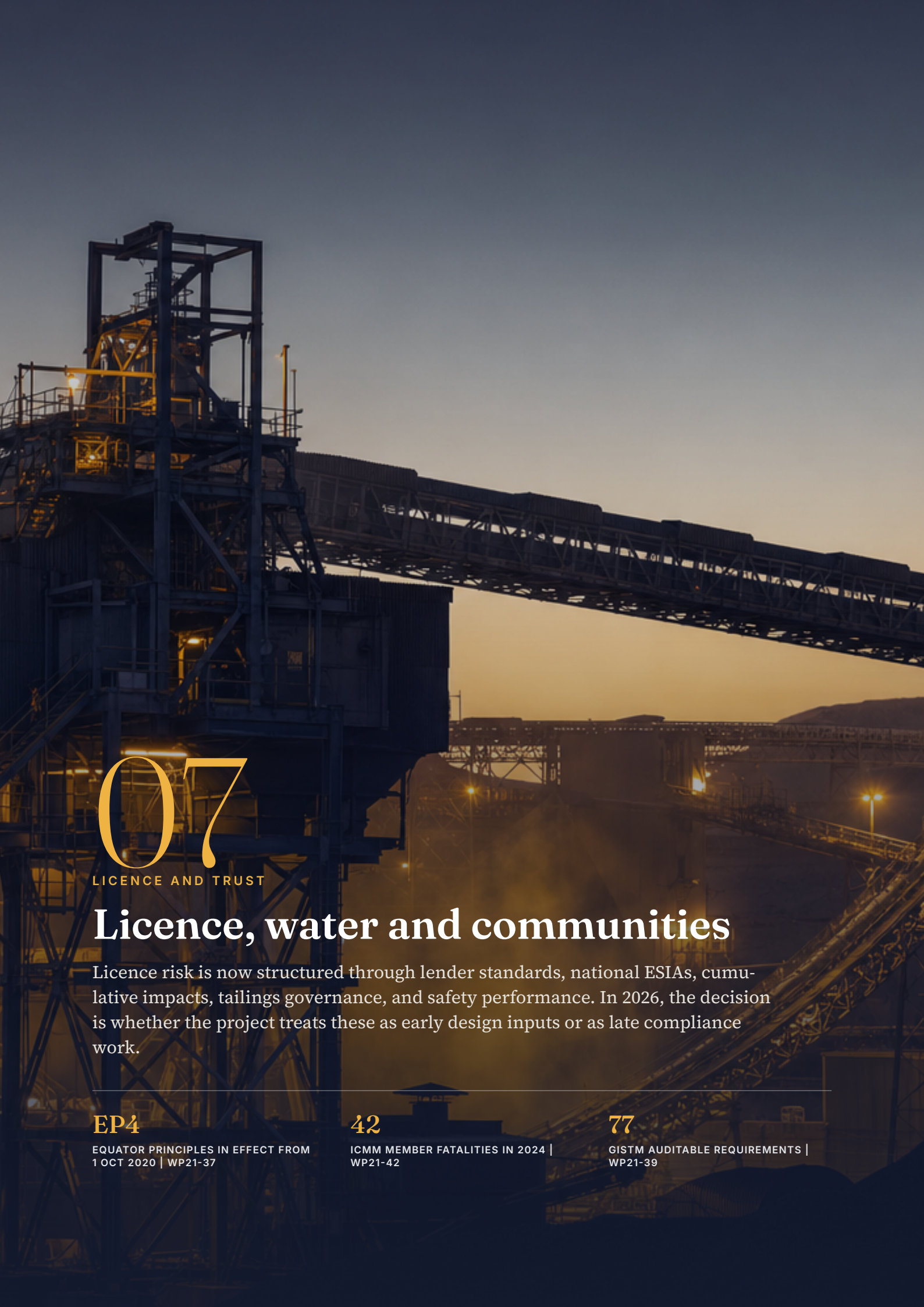
DECISION INSTRUMENT

Decision instrument: Tailings conformance scope gate for capital planning

A capital planning instrument that treats tailings conformance as scope with deadlines and assurance expectations.

TEST	EVIDENCE READING	DECISION RESPONSE
Standard structure	GISTM has 6 topic areas, 15 Principles, and 77 auditable Requirements and applies to new and existing facilities.	Map each requirement to owner scope, contracting approach, and estimate line items. Do not leave conformance as an uncosted assumption.
Deadline context	ICMM commitments set dated conformance targets by consequence category and for all operating facilities by 5 Aug 2025.	If operating facilities exist, align capital allocation and sequencing to the dated targets. Document how the project schedule interacts with conformance work.
Assurance governance	GTMI created in Jan 2025 to oversee the standard.	Define the assurance and audit approach early and include it in cost and schedule baselines.
FID condition	Tailings scope interacts with permitting and community confidence.	Set a gate that requires a conformance-aligned tailings design basis before major irreversible commitments.

Sources: WP21-39, WP21-40



07

LICENCE AND TRUST

Licence, water and communities

Licence risk is now structured through lender standards, national ESIAs, cumulative impacts, tailings governance, and safety performance. In 2026, the decision is whether the project treats these as early design inputs or as late compliance work.

EP4
EQUATOR PRINCIPLES IN EFFECT FROM 1 OCT 2020 | WP21-37

42
ICMM MEMBER FATALITIES IN 2024 | WP21-42

77
GISTM AUDITABLE REQUIREMENTS | WP21-39

7.1 Dual compliance is structural: national law plus lender standards

Environmental and social approval pathways have become structurally dual in many jurisdictions, and 2026 decisions should assume that from the start. IFC's Sustainability Framework includes 8 Performance Standards in force from 1 January 2012 and the World Bank ESF includes 10 Environmental and Social Standards applying to Investment Project Financing on or after 1 October 2018. In parallel, national regimes in Central Africa mandate ESIA, public consultation, and a government certificate before works, with differing instruments and provisions, including Cameroon's Law 96/12, DRC's Décret 14/019, Congo's Decree 2009-415, and Gabon's Law 037/2018 promulgated 11 June 2019. The decision implication is that project schedules must include both national approval steps and lender or investor standards requirements where relevant, and that teams should not assume that completing one automatically satisfies the other. Committees should require a compliance matrix that is dated and jurisdiction-specific and that identifies the controlling path for approvals.

WP21-35, WP21-38

EP4 adds a bank-led screen and risk assessment expectation that can directly change work scope. EP4 has been in effect from 1 October 2020, applies globally and to all industry sectors, and applies to project finance and project-related corporate loans and advisory above a stated threshold. It requires a Climate Change Risk Assessment for all Category A and, where appropriate, Category B projects, and it also requires this assessment for all projects where Scope 1 plus 2 emissions exceed 100,000 t CO2e per year. The decision is to treat lender categorization and emissions screening as early gates, because they can force additional assessment, stakeholder engagement, and mitigation design that affects layout, power systems, and construction methods. This is not a prediction about any specific lender decision. It is an evidence-led statement of the standard's dated requirements that 2026 projects need to plan around.

WP21-37

DECISION INSTRUMENT

Decision instrument: Dual-compliance and lender-screening matrix

A matrix to identify the controlling approval path and to prevent late-stage scope additions driven by standards triggers.

TEST	EVIDENCE READING	DECISION RESPONSE
Framework set selection	IFC PS and World Bank ESF are structured, dated frameworks with defined standards sets.	Identify which frameworks apply and assign accountable owners for each standard requirement.
National approval pathway	Central African regimes mandate ESIA, consultation, and certificate before works under listed instruments.	Map the national pathway, consultation steps, and certificate timing. Treat it as a critical path unless shown otherwise.
EP4 climate screening	EP4 requires climate risk assessment for Category A and for projects over a Scope 1 plus 2 threshold.	Screen early and decide whether to expand assessment scope. Include emissions quantification and mitigation design in early engineering.
Controlling path determination	Dual compliance can create parallel deliverables with different evidence requirements.	Decide which pathway controls schedule and align procurement and construction sequencing to that path.

Sources: WP21-35, WP21-38, WP21-37

7.2 Biodiversity, FPIC, and cumulative impacts: treat them as design constraints

Within lender standards, some requirements are strict tests rather than process steps, and they need to be treated as design constraints. IFC PS6 sets a critical habitat test that requires demonstration of no measurable adverse impacts on the qualifying values and net gains of those biodiversity values. IFC PS7 embeds Free, Prior and Informed Consent for three defined circumstances. These are high-consequence requirements because they can change where infrastructure is sited, what alternatives are viable, and what mitigation hierarchy is acceptable. In 2026 decision-making, the implication is to identify potential critical habitat and Indigenous Peoples contexts early enough to avoid design lock-in that later becomes non-compliant. The decision is to align early route selection, plant siting, and corridor alternatives analysis with the strictness of PS6 and PS7 rather than relying on late mitigation. Committees should require evidence that the project can pass the PS6 test where it is relevant, because it is stated as a measurable outcome standard, more than as a process standard.

WP21-36

Corridor and regional development patterns can also create cumulative effects that single-project ESIAs do not fully address. IFC's Good Practice Handbook on Cumulative Impact Assessment (2013) provides a six-step process designed for the private sector in emerging markets. OECD's corridor framework and corridor examples imply multi-user systems, where rail, ports, processing hubs, and settlements can interact. The decision implication is to adopt a cumulative impact approach where corridors and multiple projects are plausible, because late-stage objections and rework often arise where cumulative effects were not bounded and managed. This is also consistent with dual compliance reality: national frameworks may have varying provisions for strategic environmental assessment, while lender standards and stakeholder expectations can still demand a broader view. The decision is to define a CIA boundary, data-sharing approach, and governance early, with clear accountability across proponents where possible, rather than leaving cumulative impacts to be debated after engineering has already fixed the corridor and plant footprint.

WP21-41, WP21-26, WP21-38

DECISION INSTRUMENT

Decision instrument: High-consequence standard tests and early design decisions

A gate tool that forces early decisions when PS6, PS7, and cumulative impacts are likely to be controlling constraints.

TEST	EVIDENCE READING	DECISION RESPONSE
Critical habitat screen	IFC PS6 requires no measurable adverse impacts and net gains for qualifying biodiversity values in critical habitat.	If critical habitat is plausible, decide early whether avoidance is feasible. If not, stop and re-scope before design lock-in.
FPIC circumstances screen	IFC PS7 embeds FPIC for three defined circumstances.	Decide whether the project triggers FPIC circumstances and align engagement, alternatives, and schedule accordingly.
Cumulative impacts trigger	IFC CIA handbook sets out a six-step process; corridors introduce multi-user cumulative effects.	Adopt CIA early for corridor and hub settings. Define boundary, receptors, and governance before route and site selection is finalized.
Dual compliance interaction	National ESIA regimes and lender standards can differ in scope and evidence expectations.	Decide which requirements are stricter and design to the stricter standard where the project seeks external finance.

Sources: WP21-36, WP21-41, WP21-26, WP21-38

7.3 Safety and tailings as licence: treat implementation as the main risk control

Safety performance and tailings governance are now part of the social licence discussion because their failures are public, consequential, and often judged as preventable. ICMM's Safety Performance Report 2025 records 42 fatalities across 24 member companies in 2024, up from 36 in 2023, while TRIFR improved to 2.29 from 2.59. It also reports that Africa accounted for 50% of fatalities on 24% of hours worked and that mobile equipment was the leading hazard. The report attributes 83% of fatalities to failure to implement effective critical controls, with most control failures being ineffective execution in the operating environment. These statistics do not describe any single operation, but they show where system weakness tends to sit. The decision implication is that a licence strategy must include operational control effectiveness and verification, more than policy and training, because the evidence points to implementation as the dominant failure mode.

WP21-42, WP21-43, WP21-44, WP21-45

Tailings governance sits in the same licence and trust category because it combines technical risk with governance expectations. GISTM's structure and objective require auditable conformance and aim at zero tolerance for fatalities and zero harm, and ICMM's dated conformance commitments and the creation of GTMI in 2025 formalize assurance expectations. For mine development decisions, this means tailings facility selection, consequence classification, monitoring systems, and emergency preparedness have to be treated as board-level risks with defined controls, assurance, and reporting. In practice, this also connects to cumulative impact thinking: corridor and regional development can stress shared water resources and community resilience, making governance and transparency central. This paper does not introduce water quantity statistics because they are not in the dossier. It does state that water and community concerns will concentrate around tailings, processing, and corridor footprints and therefore must be handled under the combined standards and governance obligations already cited. The decision is to allocate resources to implementation, verification, and independent assurance as early as the project definition phase, not as

WP21-39, WP21-40, WP21-41

DECISION INSTRUMENT

Decision instrument: Licence-critical implementation gate (safety and tailings)

A gate that treats implementation effectiveness and assurance as licence-critical deliverables.

TEST	EVIDENCE READING	DECISION RESPONSE
Critical controls focus	ICMM attributes most fatalities to ineffective implementation of critical controls.	Define critical controls, assign owners, and set verification routines. Require operating-environment tests, more than design reviews.
High-risk hazards focus	ICMM identifies mobile equipment as leading hazard and notes Africa fatality concentration in its dataset.	If mobile equipment interactions are relevant, require engineered separation and operational verification as a go-live condition.
Tailings conformance scope	GISTM is auditable and applies to new and existing facilities; GTMI oversight exists from Jan 2025.	Build a conformance and assurance plan into design and capex estimates. Treat it as a gating deliverable for construction.
Transparency and trust	Standards and governance expectations define what stakeholders judge as acceptable practice.	Commit to evidence-based reporting on control effectiveness and tailings governance, aligned to the cited standards.

Sources: WP21-45, WP21-44, WP21-43, WP21-39, WP21-40

08

INTEGRATED AGENDA

The integrated decision agenda

Convert the outlook into a practical agenda: scenario integrity, corridor readiness, definition maturity, standards conformance, and implementation effectiveness as one connected stage-gate system.

Mining · Infra ·

FOUR-PILLAR FRAME USED IN THIS SERIES (ORGANISING LENS) | WP21-48

Gate

INTEGRATED GATE DISCIPLINE ACROSS PILLARS | WP21-50

STEPS

IEA LONG-RUN DEMAND MULTIPLIERS USED ONLY AS ATTRIBUTED SCENARIO CONTEXT | WP21-18

8.1 Build a single decision language across minerals, corridors, capital, and licence

The four-pillar frame used in this series is a practical way to enforce a single decision language across domains that are often managed separately. The framing row for this paper states that the year's through-line is a supply base that is high-graded, concentration-exposed, capital-constrained, and standard-bound. This is not a claim of new statistics. It is a synthesis of the cited evidence, including IEA concentration data, AACE definition discipline, and the spread of lender and tailings standards. The key governance move is to turn that synthesis into a common stage-gate set that is used by geology, engineering, logistics, environment, and finance, so that a project cannot advance on one dimension while remaining immature on another. In 2026, this matters because corridor schedules, lender screening, and conformance programs often become the controlling path. The decision is to adopt a single gate framework and apply it consistently, with dated scenario assumptions visible at every gate.

WP21-48, WP21-16, WP21-28, WP21-37

A single decision language also reduces conflict between cyclical and structural narratives. The synthesis row for this paper describes a dual signal in 2025: commodity prices broadly softened while precious metals set records and critical-minerals demand kept rising against plateaued investment. That divergence is evidenced by World Bank CMO price forecasts and IEA demand and investment statements. The integrated agenda should therefore require that each decision paper identifies whether it is primarily cyclical, such as responding to iron ore and base metals price conditions, or structural, such as responding to STEPS-labelled long-run demand. It should then identify which gates are non-negotiable regardless of price, such as definition maturity, corridor institutional readiness, and standards conformance. The decision is to prevent "price urgency" from bypassing definition and licence gates, because the evidence on cost overruns and on safety implementation failures indicates that rushed execution is a recurring loss mechanism.

WP21-49, WP21-02, WP21-04, WP21-14

DECISION INSTRUMENT

Decision instrument: Integrated stage-gate map (edition 1)

A cross-pillar stage-gate map that can be adopted without adding any new market forecast. It forces scenario labels, definition evidence, corridor readiness, and standards conformance to advance together.

TEST	EVIDENCE READING	DECISION RESPONSE
Context gate	Use only dated scenario sources such as World Bank CMO Apr 2026, WSA SRO Oct 2025, IEA STEPS outputs.	Record scenario labels and vintages. Prohibit mixing of forecast sets across commodities in one decision package.
Definition gate	AACE estimate class is determined only by definition level; FEL and PDRI provide definition maturity evidence.	Do not proceed to FID without demonstrated definition maturity and an estimate class that matches it.
Corridor gate	OECD defines corridor as hard plus institutions plus services and names recurring risks.	For corridor-dependent projects, require evidence of concession, customs, and cross-border governance readiness.
Standards gate	IFC PS, World Bank ESF, EP4, and GISTM introduce structured and auditable requirements with dated triggers and deadlines.	Define the compliance and conformance roadmap early and align engineering and stakeholder work to the controlling requirements.
Implementation gate	ICMM attributes most fatalities to ineffective implementation of critical controls; empirical cost overrun evidence shows delivery risk persists at BFS.	Resource the operating model and verification systems before ramp-up and before major change. Treat implementation capacity as scope.

Sources: WP21-02, WP21-09, WP21-18, WP21-28, WP21-33

8.2 Use corridor and trade facts to drive decision sequencing, not enthusiasm

Corridor examples and trade data should change decision sequencing, not generate enthusiasm that bypasses gates. UNCTAD's maritime trade data shows large absolute volumes and rising iron ore ton-miles, which underlines that logistics remains a material part of competitiveness. OECD's corridor definition highlights that soft infrastructure can limit throughput even when the rail exists. Lobito's published data includes length, multilateral backing, concession duration, and committed investments, and related releases cite financing totals and expected impacts. These are useful for building a corridor readiness plan, but they are not project delivery guarantees. The decision is therefore to separate three questions: whether a corridor would improve competitiveness if it performed as intended, whether the corridor has credible governance and service readiness, and whether the project has the internal definition and licence maturity to take advantage of it. Each question has different evidence and different owners. This sequencing avoids schedule shocks when corridor readiness lags mine readiness or vice versa.

WP21-11, WP21-26, WP21-23, WP21-24

Simandou provides a second case citation that supports the same sequencing discipline. Published sources describe system capacity up to 120 Mtpa, a large new multi-use rail build with extensive bridges and tunnels, and dated shipment milestones in late 2025. These citations show that even when corridor delivery progresses, the system involves complex interfaces that require integrated commissioning and ramp-up governance. The integrated agenda is therefore to build decision packs that include corridor interface registers, concession and service-level assumptions, and cumulative impacts planning where multiple users or regional impacts are plausible. IFC's cumulative impact assessment handbook offers a structured process for this, and it can be used to ensure that corridor and project proponents consider shared receptors and services early. The decision is to treat interface management and cumulative impacts as part of the corridor workstream rather than as environmental paperwork. This is consistent with OECD's corridor view and with the structured requirements in lender standards. The result is not faster approvals by default, but fewer late changes and clearer accountability.

WP21-21, WP21-22, WP21-41, WP21-26

DECISION INSTRUMENT

Decision instrument: Sequencing tool for corridor-dependent projects

A sequencing tool to avoid mismatches between corridor readiness, project definition, and licence readiness.

TEST	EVIDENCE READING	DECISION RESPONSE
Step 1: Competitiveness hypothesis	UNCTAD and OECD provide context on trade and corridor performance determinants.	State how the corridor changes freight, access, or service level assumptions and what evidence supports each assumption.
Step 2: Corridor readiness proof	OECD defines soft infrastructure and names key risks; published corridor sources provide concession and financing facts.	Require documented concession terms, customs and regulatory process plans, and service-level governance as inputs to schedule.
Step 3: Project readiness proof	AACE and FEL concepts describe definition maturity; lender standards and national law define licence pathways.	Advance mine and plant definition only as fast as corridor and licence readiness allow, and record dependencies explicitly.
Step 4: Shared impacts governance	IFC CIA handbook provides a six-step process for cumulative effects.	If multiple projects share a corridor or hub, implement CIA early with defined boundary and data-sharing arrangements.

Sources: WP21-11, WP21-26, WP21-23, WP21-33, WP21-35

8.3 Make implementation effectiveness measurable: critical controls and conformance as leading outcomes

The integrated agenda has to end in operations, because implementation failures drive both harm and economic loss. ICMM's 2025 safety reporting shows a divergence where TRIFR improved while fatalities rose, and it attributes most fatalities to ineffective implementation of critical controls, not to missing controls on paper. ICMM's updated 2026 Critical Control Management Good Practice Guide provides a structured nine-step process across planning, development, and implementation with feedback and improvement. For 2026 decisions, the implication is that implementation effectiveness should be treated as a measurable leading outcome, with verification routines that show controls are working in the operating environment. This is not a substitute for design excellence; it is a complement that addresses the observed failure mode. The decision is to require that ramp-up plans include control verification, mobile equipment interaction management where relevant, and clear ownership of critical controls. This should be integrated into project stage-gates and readiness reviews, not left to post-commissioning.

WP21-42, WP21-45, WP21-46

Conformance standards create a similar implementation agenda in environmental and tailings domains. GISTM's auditable requirements and stated objective define a governance expectation for tailings facilities, and ICMM's published conformance deadlines and the establishment of GTMI in 2025 reinforce assurance and oversight expectations. In parallel, EP4 climate risk assessment requirements and IFC and World Bank framework structures create predictable documentation and verification needs. The integrated decision agenda is to make these implementation expectations explicit in work plans and budgets and to set gates that test implementation capability before harm occurs and before large sums are committed. This agenda is also consistent with the synthesis observation that execution is the recurring failure mode across pillars, including corridor soft infrastructure and project cost outcomes. The decision is to allocate resources to implementation, verification, and governance as core scope, and to treat them as value-protecting controls rather than discretionary add-ons that can be deferred until later. This remains a synthesis framing that does not claim any specific project outcome.

WP21-39, WP21-40, WP21-37, WP21-50

DECISION INSTRUMENT

Decision instrument: Implementation effectiveness scorecard (no project data)

Capability instrument, no project data. A scorecard that can be applied internally to test whether implementation is likely to match design intent across safety, tailings, and corridor operations.

TEST	EVIDENCE READING	DECISION RESPONSE
Critical controls execution	ICMM attributes fatalities primarily to ineffective implementation of critical controls.	Score whether controls are verified in the operating environment and whether accountability is clear at shift level.
CCM process maturity	ICMM 2026 guide sets a nine-step CCM process across three phases with a feedback loop.	Score whether each phase is implemented and whether feedback drives change, more than documentation.
Tailings conformance readiness	GISTM provides auditable requirements and GTMI oversight exists; ICMM deadlines are dated.	Score whether conformance requirements are translated into operating procedures, monitoring, and assurance routines.
Corridor service governance	OECD defines corridors to include institutions and services, with named operational risks.	Score whether corridor operations have enforceable service levels, transparent pricing governance, and customs process controls.

Sources: WP21-45, WP21-46, WP21-39, WP21-26

Decision checklist

Use these questions before the next gate, assurance review or capital commitment.

01 Lock scenario vintages in every decision pack: World Bank CMO Apr 2026 for prices, WSA SRO Oct 2025 for steel demand, IEA STEPS where long-run multipliers are cited. Do not mix vintages within a single base case. [WP21-02, WP21-09, WP21-18]

02 Classify corridor dependency and require soft-infrastructure evidence, more than engineering scope: customs, concessions, regulatory alignment, and service-level governance. [WP21-26]

03 Align resource category, study stage, and estimate class. Do not fund or commit at Class 3 expectations where the project is at Class 4 or 5 definition. [WP21-29, WP21-28]

04 Treat FEL definition maturity as a funded risk control and hold a gate before FID that requires definition evidence. [WP21-33]

05 Use empirical overrun evidence to justify stronger governance, not to add a new point overrun factor to models. [WP21-30, WP21-34]

06 For transition minerals and processing, treat refining concentration and volatility as qualification parameters and document exposure explicitly. [WP21-16, WP21-15]

07 Build a dual-compliance matrix: national ESIA pathway plus applicable lender frameworks, including EP4 climate screening triggers. [WP21-38, WP21-35, WP21-37]

08 Where PS6 critical habitat or PS7 FPIC circumstances are plausible, treat them as early design constraints and decide on avoidance and alternatives before layout lock-in. [WP21-36]

09 If the setting is corridor or hub based, adopt a cumulative impacts approach early using a structured process. [WP21-41, WP21-26]

10 Treat safety and tailings as licence-critical implementation problems. Require verification of critical controls and a GISTM-aligned conformance roadmap with assurance. [WP21-45, WP21-39, WP21-40]],

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12 glossary:[{

Evidence ledger 1 of 2

This compact register lists every dossier row used in the edition. Complete statements and source descriptions remain in the citation audit and evidence dossier.

WP21-01	World iron-ore mine production ~2.6 Bt usable ore (~1.6 Bt contained iron) in 2025e, flat vs 2024
WP21-02	62% Fe CFR China averaged $99.07/t Jan:Sep 2025 vs $112.07 same period 2024; annual averages $109.4/dmt...
WP21-03	Copper: ~23 Mt mined / ~29 Mt refined 2025; annual price $9,947/mt (2025, WB); forecast $12,000/mt...
WP21-04	Gold: ~3,300 t 2025; annual average $3,442/toz (2025, WB) vs $2,388/toz (2024); forecast $4,700/toz...
WP21-05	Potash: 49 Mt K2O 2025e; KCl $348/mt (2025) vs $295/mt (2024); forecast $390/mt 2026f, $365/mt 2027f;...
WP21-06	Nickel: 3.9 Mt 2025e (+5%), Indonesia ~2.6 Mt (~two-thirds); in surplus every year since 2022 (182 kt in...
WP21-07	Zinc: 13.0 Mt zinc content 2025e; ~85 kt refined surplus 2025; price $2,868/mt (2025, WB); forecast...
WP21-08	Iron-ore monthly benchmark series: annual means $56.1 (2015) → $158.2 (2021 peak; monthly max $215.8...
WP21-09	Global finished-steel demand ~1,750 Mt 2025 (flat vs 2024); 1,773 Mt 2026f (+1.3%); China −2.0% 2025 /...
WP21-10	India steel demand ~+9%/yr 2025:26; Africa ~41 Mt 2025 (~5.5%/yr over the past 3 years)
WP21-11	World maritime trade 12,720 Mt in 2024 (+2.2%); iron-ore seaborne trade +3.5% in tons and +6.4% in...
WP21-12	Steel = ~7% of energy-sector CO2 (2.6 Gt direct/yr), largest heavy-industry direct emitter; ~8% of...
WP21-13	Preferred direct-reduction feed ≥67% Fe; high-grade (>67% Fe) scarcity is a material constraint on...
WP21-14	Lithium demand rose nearly 30% in 2024; nickel, cobalt, graphite and rare earths grew 6:8%; the energy...
WP21-15	Lithium prices fell by over 80% since 2023 (after an eightfold surge in 2021:22); graphite, cobalt and...
WP21-16	Refining market share of the top three nations rose from ~82% (2020) to 86% (2024); mining share of the...
WP21-17	Critical-minerals mining investment rose just 5% in 2024 (down from 14% in 2023); real growth just 2%;...
WP21-18	Copper demand +30% by 2040 (STEPS); announced supply −30% vs 2035 demand; lithium ×5, graphite and...
WP21-19	DRC holds ~70% of world cobalt (USGS attaches the ~70% to mine production; reserve share nearer...
WP21-20	Metallurgical coal added to the US Final 2025 Critical Minerals List (90 FR 50494, 7 Nov 2025) for its...
WP21-21	Simandou combined system capacity up to 120 Mtpa; SimFer mine ~60 M dry t/a, 30-month ramp-up; first ore...
WP21-22	More than 600 km of new multi-use trans-Guinean rail; the double-track railway has 12 stations, 206...
WP21-23	Lobito Corridor: 1,300 km rail, Port of Lobito → Luau (DRC border); multilateral backing exceeds US$10...
WP21-24	LAR secured US$753 m in development financing from the US DFC and DBSA (release 17 Dec 2025, total only,...
WP21-25	TAZARA built in the 1970s with a US$500 m interest-free Chinese loan, now operating at a fraction of its...

Evidence ledger 2 of 2

This compact register lists every dossier row used in the edition. Complete statements and source descriptions remain in the citation audit and evidence dossier.

WP21-26	OECD corridor framework: a corridor = hard infrastructure + institutions (soft infrastructure) +...
WP21-27	Benguela Railway completed 1931; Angolan civil conflict (1975:2002) cut operations to just 34 km;...
WP21-28	AACE International's estimate-classification system defines five classes keyed to project definition:...
WP21-29	Mining application (RP 47R-11): Class 5 ≈ PEA on Inferred Resources; Class 4 ≈ pre-feasibility; Class 3...
WP21-30	A review of 63 international mining and smelting projects found as-built capital costs averaged ~14%...
WP21-31	The CRIRSCO family (JORC 2012, SAMREC 2016, PERC 2021, CIM Definition Standards incorporated by NI...
WP21-32	The US SEC replaced Industry Guide 7 with subpart 1300 of Regulation S-K (adopted 2018, compliance from...
WP21-33	Front-End Loading / Front-End Engineering Design: investment in project definition before sanction (FID)...
WP21-34	Large infrastructure projects systematically exhibit cost overrun and benefit shortfall relative to...
WP21-35	IFC Sustainability Framework: 8 Performance Standards (PS1:PS8), in force 1 January 2012; World Bank...
WP21-36	PS6 critical-habitat test: in habitat of high biodiversity value the client must demonstrate no...
WP21-37	Equator Principles EP4 in effect from 1 October 2020; 10 Principles; apply globally and to all industry...
WP21-38	Central African regimes all mandate ESIA + public consultation + a government certificate before works,...
WP21-39	GISTM launched 5 August 2020, co-convened by ICMM, UNEP and PRI; 6 topic areas, 15 Principles, 77...
WP21-40	ICMM member conformance commitment: facilities with Extreme or Very High potential consequences to...
WP21-41	IFC Good Practice Handbook on Cumulative Impact Assessment (2013): a six-step process for assessing...
WP21-42	42 fatalities across ICMM's 24 member companies in 2024, vs 36 (2023), 33 (2022), 45 (2021): a sustained...
WP21-43	Africa: 50% of fatalities (21 of 42) on 24% of hours worked; FFR 0.031, the highest of any continent...
WP21-44	Mobile equipment = leading hazard 2024 (21% of fatalities; 7 of 9 in Africa); fall of ground #2;...
WP21-45	2024: failure to implement effective critical controls accounted for 83% of fatalities; 2021:2024: 67%...
WP21-46	The ICMM Critical Control Management Good Practice Guide was comprehensively updated in 2026 (first...
WP21-48	The four-pillar frame (Mining · Infrastructure · Engineering · Environment) is the paper's organising...
WP21-49	The dual signal of 2025: commodity prices broadly softened (iron ore, base metals) while precious metals...
WP21-50	The recurring failure mode across pillars is execution, not design: control-implementation failures...

Glossary

AACE estimate class

A cost estimate classification keyed to the level of project definition. AACE defines five classes from Class 5 at minimal definition to Class 1 at high definition, with accuracy ranges linked to definition, not to intent.

FEL and PDRI

Front-End Loading is investment in project definition before FID, and PDRI is a structured method to score definition maturity. Both are used to improve cost and schedule certainty by raising definition quality early.

CRIRSCO resource and reserve architecture

A common disclosure structure used by the JORC, CIM, SAMREC, and PERC family: Exploration Results to Mineral Resources to Ore Reserves, gated by a Competent or Qualified Person.

STEPS

Stated Policies Scenario used by the IEA in its Global Critical Minerals Outlook for long-run demand multipliers and supply gap statements. When cited, the scenario label should be stated each time.

Corridor soft infrastructure

Institutions and services that enable a corridor to perform, including customs processes, regulatory alignment, concession terms, and pricing governance, as distinct from physical rail and port assets.

EP4 climate change risk assessment trigger

A requirement under the Equator Principles EP4 to conduct climate change risk assessment for Category A projects and for projects where Scope 1 plus 2 emissions exceed a stated threshold.

GISTM

Global Industry Standard on Tailings Management, launched 5 August 2020, structured into 6 topic areas, 15 Principles, and 77 auditable Requirements, applying to new and existing tailings facilities.

Critical controls and CCM

Specific controls that prevent fatal or high-consequence events. ICMM's Critical Control Management guidance provides a structured process to plan, develop, implement, and improve critical controls, with evidence pointing to execution in the operating context.

Dual compliance

The practical reality that projects must satisfy both national legal requirements such as ESIA and consultation and lender standards such as IFC Performance Standards, World Bank ESF, and EP4 where applicable.

Cumulative impact assessment (CIA)

A structured approach to assess corridor-scale and cumulative effects where multiple projects or actions affect shared receptors, using a defined multi-step process.

Direct reduction feed specification (practice)

A qualitative technical practice statement that preferred direct reduction feed is at least 67% Fe, used to frame product specification constraints without implying market prevalence.

Reference-class forecasting (qualitative use)

An outside-view practice supported by empirical databases showing systematic cost and benefit bias in large projects, used here directionally without inserting new point factors.

ICMM safety metrics (TRIFR, FFR)

Reported safety performance measures used by ICMM members. In the cited report, TRIFR improved while fatalities rose, highlighting the need to focus on fatal risk controls.

FPIC

Free, Prior and Informed Consent, embedded in IFC PS7 for three defined circumstances, requiring specific engagement and consent processes rather than consultation alone.

Critical habitat net gains test

IFC PS6 requirement in critical habitat to demonstrate no measurable adverse impacts on qualifying biodiversity values and net gains of those values.

GTMI

Global Tailings Management Institute, created in January 2025 to oversee the tailings management standard and related assurance expectations.

Ton-miles

A maritime transport measure reflecting both volume and distance shipped. UNCTAD uses it to describe how trade can grow in transport work even when tonnage growth is moderate.

Metallurgical coal critical listing (US)

USGS MCS 2026 notes metallurgical coal was added to the US Final 2025 Critical Minerals List for its role in BF-BOF steelmaking.

References and limitations

United States Geological Survey (USGS) (2026)

Mineral Commodity Summaries 2026. Used for commodity production context, selected price context, and the US Final 2025 Critical Minerals List note on metallurgical coal. Rows WP21-01, WP21-02, WP21-03, WP21-04, WP21-05, WP21-06, WP21-07, WP21-20.

World Bank (April 2026)

Commodity Markets Outlook. Used for attributed commodity price history and 2026f to 2027f forecasts. Rows WP21-02, WP21-03, WP21-04, WP21-05, WP21-06, WP21-07.

Federal Reserve Economic Data (FRED) (Pull dated 2026-07-)

Global price of Iron Ore (PIORECRUSDM). Used for iron ore monthly benchmark series and annual means through May 2026. Row WP21-08.

World Steel Association (WSA) (October 2025)

Short Range Outlook. Used for finished-steel demand projections for 2025 and 2026f, including regional growth notes. Rows WP21-09, WP21-10.

United Nations Conference on Trade and Development (UNCTAD) (2025)

Review of Maritime Transport 2025. Used for world maritime trade volume, iron ore seaborne trade and ton-mile changes, and forecast growth rates. Row WP21-11.

International Energy Agency (IEA) (2020)

Iron and Steel Technology Roadmap. Used for energy and emissions shares, route energy mix, and scrap and iron ore input shares. Row WP21-12.

International Energy Agency (IEA) (2025 (retrieved 2026)

Global Critical Minerals Outlook 2025 (Executive Summary capture). Used for demand growth in 2024, price changes, concentration levels and projections, investment and exploration trend statements, and STEPS long-run multipliers and supply gap statements. Rows WP21-14, WP21-15, WP21-16,

Organisation for Economic Co-operation and Development (OECD) (2025)

Lobito Corridor Background Note. Used for corridor definition and risks, Lobito corridor facts, Benguela and TAZARA history and rehabilitation context, and regional minerals context. Rows WP21-23, WP21-25, WP21-26, WP21-27, WP21-19.

Rio Tinto (2025 to 2026)

Simandou project disclosures (captured sources). Used for Simandou system capacity, ramp-up, dated shipment milestones, and reported reserves, and for rail scope detail. Rows WP21-21, WP21-22.

International Railway Journal (IRJ) and Simandou BOT Convention Appendix 7 (2014 and 2025)

Simandou railway scope citations (captured sources). Used as cited in the dossier for rail engineering attributes. Row WP21-22.

Trafigura and US International Development Finance Corporation (DFC) and Development Bank of (2025)

Lobito Atlantic Railway financing releases (captured sources). Used for published financing total and expected capacity and cost impact claims, as attributable statements. Row WP21-24.

AACE International (1997 (captures dated)

Recommended Practices RP 17R-97 and 18R-97 (estimate classification). Used for estimate classification system and definition-based class rule. Row WP21-28.

USE LIMITATIONS

- Edition 1 vintage lock: prices and forecasts use World Bank CMO April 2026 and USGS MCS 2026; steel demand uses WSA SRO Oct 2025; critical minerals uses IEA Global Critical Minerals Outlook 2025 captured 2026-07-10. Re-verify before later editions if new vintages exist. [WP21-02, WP21-09, WP21-14]
- No Aurus point forecasts are produced. Long-run growth statements are attributed to IEA STEPS and remain scenario outputs, not project predictions. [WP21-18]
- Direct reduction feed specification of ≥67% Fe is a qualitative technical practice statement and is not presented as a transcribed market statistic. [WP21-13]
- Reference-class forecasting evidence is used qualitatively to motivate governance, not to insert new numerical overrun factors. [WP21-34]
- Corridor case citations (Simandou, Lobito, Benguela, TAZARA) are used as published examples only and do not imply any performance claim transferable to other projects. [WP21-21, WP21-23, WP21-27, WP21-25]

EDITION STATUS

This technical paper is an editorial synthesis for decision support. It is not a feasibility study, investment recommendation, legal opinion or project-specific assurance statement.

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