



IMPLEMENTATION
ENGINEERS[®]
BEYOND CONSULTING

UNDERGROUND MINING: FACE AVAILABILITY & UTILIZATION

An Implementation Engineers White Paper

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ABOUT IE MINING & METALS

IMPLEMENTATION ENGINEERS (IE) IS AN **IX®** FIRM FOCUSED ON EXECUTION.

IN MINING & METALS, WE EMBED WITH SITE LEADERSHIP AND CREWS TO OPERATIONALIZE THE ALIGN–DESIGN–EXECUTE CADENCE: SHORT-INTERVAL CONTROL AT THE HEADINGS, DISCIPLINED MOS, RELIABILITY AND MAINTENANCE INTEGRATION, AND PRAGMATIC DIGITAL/ANALYTICS (E.G., DRILL TELEMETRY/MWD, FRAGMENTATION SENSING, CMMS/ERP REPORTING). THE OUTCOME IS PREDICTABLE METERS, LOWER DILUTION, STEADIER PLANT FEED, AND VISIBLE FINANCIAL RESULTS.

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THE HIDDEN LEVERAGE POINT IN UNDERGROUND MINING

WALL/FACE AVAILABILITY & UTILIZATION AS THE PRIMARY DRIVER OF THROUGHPUT, RECOVERY, AND COST

An Implementation Execution (IX®) perspective on turning headings into EBITDA.

EXECUTIVE SUMMARY

Underground mines are often managed around lagging outputs — tons hauled, meters advanced, or mill throughput. Yet the single most powerful leading indicator of stable production is the **availability and utilization of drilling faces**. When faces are not physically ready (ground support, services, survey, ventilation) or not utilized effectively (drill patterns, sequencing, charging, blast QA/QC), the mine's rhythm breaks. The consequences are predictable: poor fragmentation, higher dilution, slower load-haul, unstable plant feed, and rising unit costs.

Implementation Engineers' **IX®** approach reframes underground production control around **face readiness and utilization**. We operationalize a practical KPI stack, a short-interval control cadence, and a heading pipeline model that links planning to shift execution. The result is measurable improvements in advance rate, reduced dilution, higher plan adherence, and a durable increase in EBITDA per tone.

What changes when the face becomes the heartbeat:

- Advance meters stabilize, fragmentation meets target more consistently, and mucking cycles accelerate.
- Dilution drops via perimeter control and pattern discipline; recovery improves at the plant.
- Crew time shifts from firefighting to predictable, high-value cycle work; maintenance is less reactive.
- Leaders manage with **leading indicators** (face bank, readiness index, utilization) rather than chasing yesterday's tons.

By treating the face as the heartbeat and managing to leading indicators, mines convert hidden preparation losses into steady, bankable tons.

1. WHY THE FACE CONTROLS THE MINE

A mine is a sequence of dependent operations. Underground, that dependency converges on the drilling face. If the face is unready or underutilized, every downstream step starves or becomes inefficient:

- **Fragmentation:** Inconsistent burden/spacing and charging → coarse or uneven muck → lower LHD bucket fill, higher dig times, more hang-ups.
- **Dilution:** Overbreak and poor perimeter control → waste to mill → lower head grade and recovery.
- **Load & Haul:** Irregular advance and brow condition → cycle variability, more tramming per tone.
- **Plant Yield:** Variable feed size and grade → unstable throughput and lower recovery.
 - In practice, 25–40% of potential production time is often lost to face unavailability or mis-sequenced readiness work. Bringing rigor to **face readiness** and **utilization** is the fastest way to reclaim capacity without adding equipment.

2. KPIS THAT PREDICT TONNAGE (CONTEXT + DEFINITIONS)

When leaders see the face as the mine's heartbeat, the KPIs stop being isolated numbers and start telling a story. **Readiness** (can we work the face?), **utilization** (are we actually working it?), and **quality** (did we work it to spec?) combine to drive **advance performance** and, ultimately, sustained tons at the mill. The stack below keeps that causal chain intact and makes it visible at the shift and heading level.

2.1 AVAILABILITY & READINESS

- **Drill Rig Availability (DRA)** = (Scheduled drill time – Unplanned downtime) / Scheduled drill time.
Why it matters: If the rig isn't available, it doesn't matter how good the plan is—DRA sets the ceiling on what's possible this shift.
- **Heading Availability (HA)** is a gating check of physical readiness: **HA = Ready Time / Scheduled readiness window**. "Ready" means eight gates are green: ground support/scaling, survey & pattern loaded to the rig, ventilation & gas clearance, services (power/air/water/comms), access/roadway, slot/void (if longhole), Geotech sign-off, and permits/controls.

Why it matters: HA exposes the quiet killers—survey lag, services not moved, or vent not extended—that silently steal meters before a bit ever turns.

- HA = Ready Time / Scheduled readiness window.
- *Ready* means all of the following are greenlit:
 - 1) Ground support/scaling complete,
 - 2) Survey marks set and pattern loaded to rig,
 - 3) Ventilation and gas clearance,
 - 4) Services (power, air, water, comms) in place,
 - 5) Access/roadway maintained and free of obstructions,
 - 6) Slot/void condition adequate (for longhole stoping),
 - 7) Geotech conditions assessed and accepted,
 - 8) Permit/controls cleared.
- **Face Readiness Index (FRI)** (0–100): weighted score of the eight readiness gates above. Example weights: Geotech 20, Ground Support 15, Survey 15, Vent 10, Services 10, Slot 10, Access 10, Permits 10. A face is **Ready** when FRI ≥ 85 and no critical red gates.

Why it matters: FRI turns a go/no-go judgement into an objective standard and a coaching tool. It's also the best early-warning signal for tomorrow's tons.

2.2 UTILIZATION & CYCLE QUALITY

- **Face Utilization (FU)** = Productive drilling time at face / Face available time.
Why it matters: FU converts readiness into meters. A big gap between HA and FU means operational loss—redeployments, waits, or sequencing issues.
- **Charge/Blast Readiness (CBR)** = Charges executed to design / Charges planned.
Why it matters: CBR links design intent to execution. Low CBR is a leading indicator of fragmentation issues and overbreak.
- **Fragmentation Quality Index (FQI)** = % of blasts hitting spec (e.g., P80 target ± tolerance) using image/on-bucket vision.

Why it matters: FQI predicts LHD cycles and plant stability. Out-of-spec fragmentation shows up as slower mucking long before it appears in mill KPIs.

- **Overbreak Compliance (OC)** = % perimeter within tolerance vs design.

Why it matters: OC keeps dilution in check. It's the fastest way to protect grade without starving production.

2.3 PERFORMANCE & COMPOSITE INDICES

- **Advance Performance (AP)** = Actual advance per drilling hour / Target advance per drilling hour.

Why it matters: AP blends geology, rig condition, and operator technique into one number — ideal for focused coaching.

- **Overall Face Effectiveness (OFE)** (analogous to OEE):

$$\text{OFE} = \text{HA} \times \text{DRA} \times \text{FU} \times (\text{FQI}) \times (\text{OC}) \times (\text{AP})$$

Why it matters: Like OEE for manufacturing, OFE gives a fair comparison across headings and makes loss waterfalls obvious.

Normalize FQI, OC, and AP to 0–1 scales. Use OFE to compare headings and focus coaching and engineering effort.

2.4 LEADING “HEARTBEAT” INDICATORS

- **Face Bank:** number of fully ready headings vs. plan by shift and 14-day look-ahead. Target: 1.2–1.5× the faces needed to keep drills and LHDs fully utilized.

Why it matters: A healthy bank protects production from normal variability.

- **Readiness-to-Utilization Delta (RUD)** = HA – FU (high RUD = operational inefficiency at the face).

Why it matters: Rising RUD = “we got it ready but didn’t use it.” It points to dispatching and sequencing gaps you can fix this week.

- **Face Velocity:** headings advanced per day (trendline by area/level).

Why it matters: Turns a pile of shift numbers into a pace line leaders can manage to.

3. DIAGNOSTIC FRAMEWORK THAT LEADS TO ACTION

A delay code dictionary is only useful if it explains losses and suggests owners. We group delays so the right triad (Ops, Tech Services, Maintenance) knows what to fix and who leads. In practice, most mines see 3–4 codes dominate each area — your Pareto tells you exactly where to sprint.

Categories with intent:

- A. **Physical Readiness** (scaling, support, survey, vent, services, access, slot/brow) → *owned by Tech Services with Ops support.*
- B. **Operational** (crew change, windows, explosives logistics, rework) → *Ops lead.*
- C. **Equipment/Technical** (rig/mech/electrical, tooling, telemetry) → *Maintenance lead.*
- D. **Geotechnical** (structure, water, re-support) → *Geotech lead.*
- E. **Safety/Permits** (inspection holds, barricades) → *Shared, Safety chair.*
- F. **Logistics/Services** (vent bag/cable/water moves) → *Ops + Services.*
- G. **Planning/Coordination** (double booking, sequence conflicts, survey backlog) → *Planning chair.*

How we use it weekly: validate codes in the field, publish a level-by-level Pareto, run a 2-week sprint on the top two causes, and re-check OFE. If codes don't change, the fix wasn't actually installed.

4. THE HEADING PIPELINE (CONTROL WIP UNDERGROUND)

Treat headings like a production pipeline with explicit WIP limits.

Stages: Prep → Survey/Mark-up → Drill → Charge → Blast → Vent Clear → Muck → Support/Services → Ready

WIP caps stop clogging (e.g., too many blasted but un-mucked headings that block access). Use Little's Law to size the pipeline.

- **Policy:** Maintain a *Face Bank* that protects drills and LHDs from starvation. Set WIP caps per stage to avoid clogging (e.g., too many blasted un-mucked headings that block access).

- **Little's Law for headings:** Avg. headings in process = Throughput (headings/day) × Cycle Time (days/heading). Use this to size the bank and staffing.
- **Buffers:** Time buffer before drill (readiness), capacity buffer for LHDs, and material buffer (explosives/consumables) sized via historical variability.

So what: A controlled pipeline releases a steady stream of “Ready” faces, which keeps rigs/LHDs fed and plan adherence high without adding equipment.

5. PLANNING & SIC YOU CAN RUN EVERY SHIFT

Connect horizons so decisions flow: a **13-week plan** for stopes/development, raises, and PM windows; a **14-day look-ahead** that shows which faces will be truly ready; and **shift control** that locks the next 12 hours.

The daily cadence is simple: pre-shift readiness huddle (confirm face bank and red gates), a mid-shift check (fix any delay >15 minutes or redeploy), and an end-of-shift review (update gates, log delays, set next-shift priorities).

Leader standard work ties it together: supervisors audit FRI and code accuracy; engineers reconcile the face bank and update the look-ahead; the Ops/Maintenance/Tech triad reviews OFE and runs the next constraint sprint.

Horizon integration:

- **Quarterly–13 Week Plan:** Stope/development portfolio, slot/raise calendar, equipment PM master schedule.
- **14-Day Look-Ahead:** Daily map of Ready/Not Ready faces, service moves, survey workload, PM windows, blasting windows.
- **Shift Control (SIC):**
 - Pre-shift readiness huddle at the level: confirm face bank, green/red gates, risks.
 - Mid-shift check (radio/board): address delays >15 minutes; redeploy if RUD ↑.
 - End-of-shift review: update readiness gates, delay capture, next-shift priorities.
- **Leader Standard Work (LSW):**
 - Supervisor: face readiness audit (FRI spot-check), delay validation, SIC cadence adherence.

- General Foreman/Engineer: daily face bank reconciliation, look-ahead updates, critical path call-outs.
- Operations/Maintenance/Technical triad: weekly constraint review using OFE and Pareto.

Why this works: the plan adapts to heading reality in near-real time, so you stop losing meters to yesterday's assumptions.

6. TECHNOLOGY ENABLERS (PRAGMATIC, NOT SHINY)

Start with the data you already have and wire it into the cadence. Drill telemetry/MWD helps adjust patterns and charging *in shift*; navigation/guidance closes the loop with as-drilled patterns; simple fragmentation sensing at the face or on LHD buckets turns “looks okay” into a spec; a digital readiness board makes FRI gates visible; integrated delay capture enforces one dictionary across rigs/LHD/charging; and a light predictive layer forecasts which faces will miss readiness or fragmentation next week.

- **Drill Telemetry & MWD (Measure-While-Drilling):** hole deviation, penetration rate, torque/pressure → infer rock mass variability and adjust patterns/charging in-shift.
- **Navigation/Guidance:** on-rig pattern loading from mine planning (Deswik/Datamine/MineRP) with closed-loop as-drilled data.
- **Fragmentation Sensing:** vision systems at the face or on LHD buckets for real-time P80/P50 estimates; use alarms when outside tolerance.
- **Digital Readiness Board:** mobile app/tablet with FRI gates and sign-offs; red/amber/green status feeds the look-ahead.
- **Integrated Delay Capture:** common code dictionary across rigs, LHDs, and charging crews; auto-populate from telemetry where possible.
- **Predictive Models:** forecast face readiness and fragmentation risk from historical delay patterns, geotech flags, and MWD signatures.

Principle: Start with data you already have; connect systems to the SIC and MOS. Fancy tech without cadence won't stick. Tools amplify discipline; they don't replace it.

7. BEHAVIORS & MANAGEMENT OPERATING SYSTEM (MOS)

Data informs; behaviors transform. Make the work visible (ready faces, active patterns, RUD hotspots at each level). Assign named owners per readiness gate so “survey is late” becomes “John’s gate is red.” Coach with purpose — use OFE to pick one behavior per crew per week (pattern compliance, perimeter control, or charging QA). Lock standards into checklists and audits, then skill people through short, practical modules (drilling economics, fragmentation-to-LHD linkage, and clean delay coding):

- **Visual Control:** level-by-level boards of Ready faces, active patterns, and RUD hotspots.
- **Accountability:** named owners for each readiness gate per heading (survey, ventilation, services, support, charging).
- **Coaching:** use OFE to guide ride-along coaching; focus on one behavior change per crew per week.
- **Standards:** pre-shift readiness checklist; blast QA/QC checklist; pattern compliance checks; perimeter control sign-off.
- **Training:** Implementation University modules on drilling economics, perimeter control, fragmentation to LHD linkage, and delay coding discipline.

Result: fewer firefights, more predictable meters, less reactive maintenance.

8. CASE SNAPSHOTS (ANONYMIZED COMPOSITES)

Gold — Longhole Stopping:

- Baseline: 28% of planned faces not ready; unplanned dilution +12%; mucking delays common.
- IX® Actions: readiness gates and FRI; 14-day face bank board; perimeter QA/QC; drill telemetry to adjust burden; weekly OFE review.
- Results (12 weeks): Ready faces ↑31%; drilled meters/shift ↑22%; dilution ↓9%; 14-day plan adherence 94%.

Nickel — Development Focus:

- Baseline: schedule churn due to survey/service backlogs; rig downtime poorly classified.

- IX® Actions: delay taxonomy; service move playbook; LSW for mid-shift redeploys; predictive readiness for survey.
- Results (10 weeks): Face Utilization ↑18 pts; development advance/shift ↑15%; unscheduled rig downtime ↓27%.

Polymetallic — Narrow Vein:

- Baseline: chronic overbreak at hanging wall; high dilution to mill.
- IX® Actions: perimeter control training; modified pattern with trim holes; charge QA at brow; image-based fragmentation/dilution monitoring.
- Results (8 weeks): OC compliance ↑25 pts; dilution ↓6%; stope recovery ↑4%; LHD cycle time ↓8%.

Note: Results are composites representative of IX® implementations; site specifics vary.

9. FROM METRES TO EBITDA (CONNECTING THE DOTS)

Tie technical gains to value in plain language. Throughput uplift comes from higher advance at steady quality; dilution cuts protect head grade and recovery; quality and cycle improvements reduce unit cost; and recovered capacity often defers capex (one less rig or LHD this year). Present the result as a waterfall: first reclaim availability losses, then lift utilization, then stabilize quality/velocity, then capture cost per tone. Validate with a 90-day pilot so finance can see the run-rate before the wider roll-out.

- **Throughput uplift:** Δ (Delta) Advance Rate $\times$ Faces active $\times$ Ore density $\times$ Grade $\times$ Price $\times$ Recovery.
- **Dilution reduction:** Δ (Delta) Dilution $\times$ Tons processed $\times$ (NSR difference ore vs. waste) $\times$ Recovery impact.
- **Cost effects:** fewer re-drills/rehab; lower mucking/secondary breakage; reduced overtime; maintenance MTTR/MTBF improvements via lower shock loads.
- **Capital deferral:** recovered capacity reduces need for additional rigs/LHDs.

Provide a **benefit waterfall**: (1) recovery of lost time (availability) $\rightarrow$ (2) higher utilization $\rightarrow$ (3) quality & cycle speed $\rightarrow$ (4) cost/unit improvements. Validate with a 90-day pilot before full roll-out.

10. IMPLEMENTATION ROADMAP — IX® ALIGN • DESIGN • EXECUTE

i. Phase 1 — Align

- Rapid readiness/OFE baseline; delay taxonomy install; leadership alignment on KPI definitions; face bank sizing.

ii. Phase 2 — Design

- SIC/LSW design; readiness gate ownership; digital boards; telemetry/data connectors; training curriculum; pilot scope.

iii. Phase 3 — Execute

- Pilot two areas/levels; weekly constraint reviews; behavior coaching; dashboard hardening; fragmentation/dilution control; predictive readiness tuning.

iv. Sustain

- MOS audits, quarterly refresh of delay dictionary; cross-site benchmarking; Implementation University certification for supervisors and engineers.

11. DATA ARCHITECTURE & DASHBOARD WIREFRAME

Data sources: rig telemetry, MWD, charge sheets, survey database, ventilation/permit app, LHD telemetry, shift logs, maintenance CMMS.

Core visuals:

- **Face Bank** by area/shift with FRI gates (RAG status).
- **OFE by heading** with drill-down to HA, DRA, FU, FQI, OC, AP.
- **RUD Hotspots** heatmap; delay Pareto by taxonomy.
- **Fragmentation vs. LHD Cycle** scatter to link quality to productivity.
- **Plan Adherence** (14-day look-ahead vs. actual) with reasons for variance.

Governance: data lock times per shift; single-source hierarchy; change control for KPI definitions.

12. RISK & CONTROL (SAFETY AND GEOTECHNICAL FIRST)

- Never compromise ground stability for utilization. Readiness gates formalize **stop-work authority**.
- QA/QC on charging and perimeter control lowers geotech risk and reduces secondary breakage.
- Ventilation and gas clearance are non-negotiable gating items; automation should not erode discipline.
- Data governance avoids “wrong-decisions-fast.” Validate telemetry against field checks.

13. CONCLUSION — MAKE THE FACE THE HEARTBEAT

Underground becomes predictable when readiness, utilization, and quality are managed as one system.

When the drilling face is **ready, utilized, and controlled**, underground operations become predictable: fragmentation meets spec, dilution falls, LHDs cycle faster, plant feed stabilizes, and costs come down. The IX® method hardwires this control into the mine’s daily rhythm through clear KPIs, disciplined SIC, and practical tech enablement.

If advice hasn’t moved your tons, execution will.

APPENDICES

A) DELAY CODE STARTER SET (EXCERPT)

- **Readiness:** SURV-WAIT, VENT-WAIT, SVC-MOVE, GSUP-PEND, ACCESS-CLR.
- **Operational:** CREW-LATE, CHG-LOG, QA-HOLD, BLST-WND.
- **Equipment:** RIG-MECH, RIG-ELEC, TOOL-STL, TEL-LOSS.
- **Geotech:** GEO-WTR, GEO-STRUCT, GEO-BURST.
- **Safety/Permits:** SAFE-INSP, PERM-HOLD.
- **Logistics:** MAT-TRAF, EXP-DELAY.
- **Planning:** SEQ-CON, SLOT-MIS, SURV-BKLG.

B) EXAMPLE TARGETS (TO BE SITE-TUNED)

- **FRI ≥ 85** for Ready; **FU ≥ 70%**; **FQI ≥ 85%** within P80 spec; **OC ≥ 90%** within perimeter tolerance; **OFE Trending +10 pts** in 90 days; **Plan Adherence ≥ 92%** on 14-day schedule.

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