



GMG SYDNEY COLLABORATORY 2026

OUTCOMES REPORT

EXECUTIVE SUMMARY

The GMG Sydney Collaboratory brought two projects — Rethinking Mine Design and Zero Entry Mining — into the same room over two days at UNSW Sydney, alongside the ARC Research Hub for Next Generation Mining Methods. The two days used deliberately different methods on deliberately different questions and arrived at compatible answers. The two days were built to be commensurable — different methods, the same underlying question.

Five key themes emerging from the Forum:

The Enabling Infrastructure Loses Because Nothing Makes It Win

Comms and Power Reticulation were the first cut, and their absence is what made the shocks unanswerable. There is no rule requiring them and no accepted method for valuing what they preserve, so a decision-maker choosing between a certain cost now and an unvalued option later makes the same choice every time.

Financial Evidence is the Binding Constraint

Capital allocation, cost of capital, hedging and risk tolerance were named as what practitioners were never taught to ask. Zero Entry will not be rejected because the technology lacks potential, but because the financial data model runs on assumptions with no real-world data behind them.

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Cost-early, Benefit-late Structures

Participants met the cost-early, benefit-late structure as an experience, when the ones that had cut the cheap enabling items found they had no answer to the shocks. Fix one objective and the loop becomes a line. A finding reached three ways by three methods, as robust as this kind of evidence gets.

Unsettled Arguments of the Safety Case

The safety case was challenged from the floor and conceded by the project's leadership on the evidence of how truck automation was actually sold—with value first and safety as the byline.

Capture is the Recurring Failure

Participants increasingly viewed Zero Exposure / Zero Entry Mining as an achievable progression rather than a distant vision, enabled by advances in automation, electrification, connectivity, and remote operations.

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FORUM OVERVIEW

Day One asked where in a project's life a technology-led design stops being possible. Six tables took a fictional but fully specified copper-gold project from concept to execution over three rounds. Between rounds, the project was handed to another table and only the decision sheet travelled; no reasoning, no context, no right of reply. At the end, shocks landed, and each table scored the mine it had inherited.

Day Two asked a structural question instead: if a technology-led design keeps losing, what is it about the system that makes the losing the rational call? Six tables each took one lens – Greenfield, Brownfield Transition, People and Capability, Interoperability and Data, Business Case and Capital, and Safety, Legal and Social License – drew the Zero-Entry system as a casual-loop map with reinforcing and balancing loops named, placed evidence cards down from Helsinki, Sudbury, and the exploratory white paper onto their maps, nominated leverage points against a five-rung ladder, and then wrote a chapter skeleton.

SESSION HIGHLIGHTS

Rethinking Mine Design

Participants played the Optionality Game, a simulated copper-gold project where six tables made staged investment decisions under fixed budgets, inherited decisions from other tables, and then faced shocks such as price collapse, diesel bans, injuries, grade misses, and power constraints.

Key Takeaways

- Every table protected social license, but most sacrificed energy flexibility.
- Communications and Automation were treated as discretionary and cut early.
- Optionality was often lost before anyone realized it.
- The most successful table preserved options by moving Energy and Communications from capital to operating expenditure.
- Engineers identified gaps in finance, capital allocation, risk and project purpose—not technology—as what they had been taught not to ask.

Zero Entry Mining

Participants mapped the system around Zero-Entry mining using casual-loop diagrams, leverage points, and chapter skeletons for future papers.

Key Takeaways

- Regulation mandates were seen as major levers.
- The industry lacks accepted financial evidence for Zero-Entry benefits.
- The cost of enabling infrastructure arrives early, while benefits arrive late and system-wide.
- Productivity remains a contested claim.
- Safety alone may not be the strongest lead argument—value, productivity, stewardship, and regulation all emerged as possible framings.





The Cheapest Options Are Cut First

The Day 1 simulation gave every table the same \$200 million per round and the same menu of options. Social licence was bought at every table, usually near the top of its price band. Communications and power reticulation — priced at \$10M and \$5M, the two cheapest items on the entire menu — were the recurring casualties, cut to protect costlier line items such as the shaft or material handling. Four of the five tables that completed an "optionality trace" named energy or the communications infrastructure it depends on as the option that was lost, and in most cases the loss was only noticed a full round after the decision that caused it.

The consequence showed up later, not at the point of decision. When shocks were applied five years on, the tables that had cut communications and power had no way to respond — one recorded finishing with "no power, no comms, little opportunity to reduce exposure" when an injury shock landed. The two tables that scored best did not out-engineer the others: one moved energy and communications from capital to operating expenditure to protect its core budget, and the other preserved flexibility simply by not committing to a power source at all.



Discussion takeaway: Enabling infrastructure loses because nothing makes it win. There is no rule requiring it and no accepted method for valuing the optionality it preserves, so it loses to costlier, more visible priorities every time.

Design Decisions Made Years Before Execution Set the Ceiling

A plenary on the mine-design process argued that of the recognised stages from scoping through execution, only pre-feasibility formally mandates that design trade-offs be tested at all — typically eight to ten years before execution and while only the highest-confidence part of the orebody is known. Combinatorics make the scale of the problem concrete: cut-off grade alone yields ten or more options, and combined with access and processing alternatives the design space runs to roughly a thousand cases, of which only a handful are ever modelled.

The simulation demonstrated the same point experientially. Charters were written and sealed before any table saw a single option; tables that named safety, community and environment alongside financial return in their charter scored highest once shocks arrived, while a schedule-and-budget-only charter left one table with no basis to recover. Participants also noted that design intent itself does not survive a handover: the exercise forbade recording why a decision was made, and tables that inherited a project inherited a column of numbers with no reasoning behind it.



Discussion takeaway: By the time a scope is fixed, the opportunity to design in new technology has usually already gone. Trade-offs need to be re-opened later than pre-feasibility, and the reasoning behind early decisions needs to travel with them, not just the numbers.



The Constraint is Financial and Organizational, Not Technical

Asked what they had never been taught to ask, every Day 1 table wrote back a version of the same answer: capital allocation, cost of capital, hedging, risk tolerance, and what the mine is actually for. Not one card named a missing technology. The Day 2 Business Case chapter converted this into a research agenda, with its central claim that zero entry will not scale until safety, productivity, resilience and mine-life benefits are converted into credible financial evidence and released through staged, risk-sharing capital structures. Its sharpest line was that a board may reject zero entry not because the technology lacks potential, but because the financial model rests on assumptions with no real-world data behind them.

A recurring barrier compounded this: benefits are frequently unexpected and therefore cannot be quantified when a business case is first written, and once a mine's capital budget is locked, it is very difficult to argue for more. Participants also noted that decarbonisation capital already exists as a driver for electrification, but no equivalent driver currently exists for autonomy — despite electrification being what makes automation easier to justify.



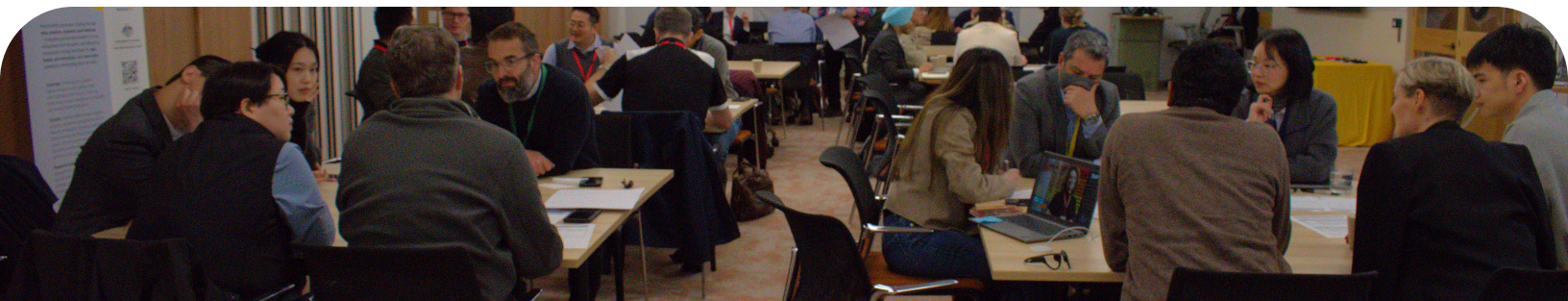
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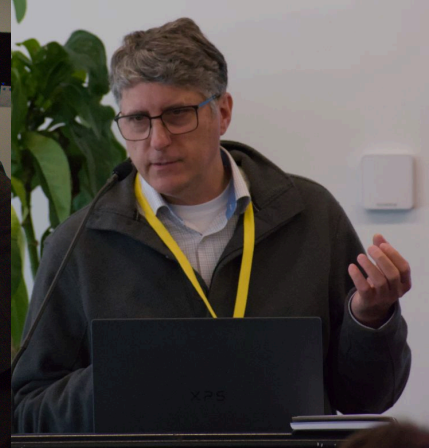
Zero Entry is a Mindset Problem Before it is an Equipment Problem

Zero entry mining was defined precisely during Day 2: no person in the mine while the process is running, not the absence of people from mining altogether. The case for it was made on cost as much as safety — ventilation alone can run to half or more of a deep underground mine's operating cost, and useable working time within a shift falls sharply at depth, whereas a machine that is only three-quarters as efficient as a person can still work continuously. Removing people also removes the need for much of the infrastructure built to protect them: ventilation, refuges, secondary egress and conservative ground support. The working groups converged on a similar view of where the leverage sits. Across the six system maps, participants nominated a regulatory mandate or a shift in industry mindset as the primary leverage point far more often than a tunable parameter — one table's stage-gated capital release was the single parameter-level nomination across all six groups. Several rules that currently prevent efficient automated work — such as restrictions on drilling near a loaded blast hole — were noted to have been written to protect people rather than to reflect physical law, and are candidates for re-examination once exposure, not just the hazard, has been removed.



Discussion takeaway: Zero entry mining is not a technology retrofit. It is a redesign of the mine, its rules and the roles people perform — and the room's own instinct was that changing mindset and regulation matters more than changing equipment.





How to Argue for it is Genuinely Unsettled

The most consequential exchange of the two days was a direct challenge to the safety-first framing usually used to justify zero entry: a participant argued that, measured against everyday road deaths and injuries, a safety case alone will not carry the argument, and that productivity and radical change are the stronger case. The project's own leadership conceded the point from operating experience, describing how truck automation was actually sold internally: on the value of higher utilisation, with elimination of injuries and deaths presented as the secondary benefit rather than the lead argument.

No participant opposed zero entry as a goal. The disagreement was entirely about the order of the argument, and at least three competing leads were put forward in the room: productivity and radical change, resource stewardship (better economics allow a lower cut-off grade and less wasted metal), and a regulatory case built on the observation that proven technology has existed for two decades without adoption following. The room did not resolve which should lead, and several participants argued the opposing case on regulation itself — some saying it drives innovation, others that it only bites when a regulator forces it.



Discussion takeaway: The technology and safety case for zero entry is largely made. The unresolved question is which argument — value, safety, or stewardship — should be put to a board first, and it should be settled deliberately rather than left to habit.

Capture is the Recurring Failure

Day 1 built the loss of intent into its own rules: tables were told not to record why a decision was made, only what was decided, and every subsequent table inherited numbers without reasoning. Day 2 experienced the same failure by accident rather than by design — the chapter-drafting session, the gallery walk of posters and the sign-up for chapter ownership were not captured on any recording, leaving several of the nine discussion-paper threads with a stated claim but no confirmed author.

The parallel was not lost on participants: several noted, independently, that the same handover problem — design compromises paid for later by whoever inherits the project, with no record of why they were made — is exactly what they experience moving from planning to construction to operations in their own projects. The practical fix identified was straightforward: confirm authorship and intent in writing immediately after a working session, rather than assuming it will be recoverable later.



Discussion takeaway: The event reproduced, at its own expense, the exact handover problem both projects exist to solve. Recording the reasoning behind a decision — not only the decision itself — has to be a deliberate, enforced step, not an assumption.



WHAT THIS MEANS FOR THE INDUSTRY

- Enabling infrastructure needs a rule or a valuation method, or it will keep losing. Communications and power are cheap enough to be cut without visible short-term cost, and expensive to be without once conditions change.
- Design trade-offs need to be reopened later than pre-feasibility. A single early-stage test of alternatives, on partial orebody knowledge, is not enough to keep zero entry or automation on the table by execution.
- The business case for zero entry and automation has to be built as a financial case, not a technical one — with credible baselines, real-world evidence and staged capital release, not assumption-driven models.
- Zero entry mining is a redesign of rules, roles and mindset as much as of equipment. Rules written to protect people from a hazard that no longer applies once exposure is removed are candidates for re-examination.
- The order of argument for zero entry — value, safety or stewardship — should be a deliberate choice, informed by how automation has actually been sold successfully before, not a default.
- Reasoning has to travel with decisions, not just outcomes. Whoever inherits a project, a decision, or a chapter needs the 'why', recorded at the point it was made.



OPPORTUNITIES FOR THE GMG COMMUNITY

- ➔ Publish the Optionality Game as a Rethinking Mine Design Foundations case study, including a centrepiece figure tracing what optionality was lost, when, and why across the six simulated projects.
 - ➔ Develop a companion primer on capital allocation, hedging and cost of capital for study managers — the gap named independently by every Day 1 table.
- Build the proposed Safety-Social-Techno-Economic Model: a comparison tool that lets a base case be weighed against a zero-entry case on cost, safety and social terms side by side, since existing economic models do not capture the human and community cost.
- ➔ Commission the four discussion-paper threads that received no author at Sydney — mining methods, systems engineering approach, enablers and barriers, and legal and ethical — alongside the five that already have a drafted skeleton.
 - ➔ Build a definitions chapter for zero entry mining from the annotated poster series, distinguishing hazard from exposure, automation from autonomy, and setting out the surviving human roles of supervision and monitoring.
 - ➔ Consolidate the Sydney, Sudbury and forthcoming Perth outputs into a single master document, and settle the order-of-argument question (value, safety, stewardship) before the paper series is finalised.



CONCLUSION

The Sydney Collaboratory did not settle zero entry mining or mine design as finished arguments. It showed, from two different directions, that the barriers are the same ones the industry already suspected: the cheapest, most enabling infrastructure is cut first because nothing requires it; design decisions taken early foreclose options that are only missed much later; the constraint on adoption is financial and organizational rather than technical; and even the industry's own advocates are not yet agreed on how best to make the case.

The strongest result of the two days was structural, not rhetorical: a funding simulation and an independently drawn causal-loop map, run a day apart with no cross-contamination, converged on the same conclusion — that early commitments turn a system that could be revisited into one that cannot. For the GMG community, the practical opportunity is the same one identified at Sudbury: shared evidence, common frameworks and deliberate capture of the reasoning behind decisions, so that proven ideas move from isolated pilots — or isolated workshops — into durable practice.

