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Divergent thinking

The value-add proposition in mining consulting

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For owners of mineral assets, efficient and cost-effective project development is critical for achieving value. Unfortunately, too many executive teams are taking shortcuts in their development projects to conserve money and time, thereby doing exactly the opposite and exposing their shareholders to lost opportunities. Most project participants can tell you that the study process for a project moves from scoping study (SS) to prefeasibility study (PFS) to definitive feasibility study (DFS) and detailed engineering (ie operational readiness), with precision in the estimates improving as more information comes to hand (Table 1).

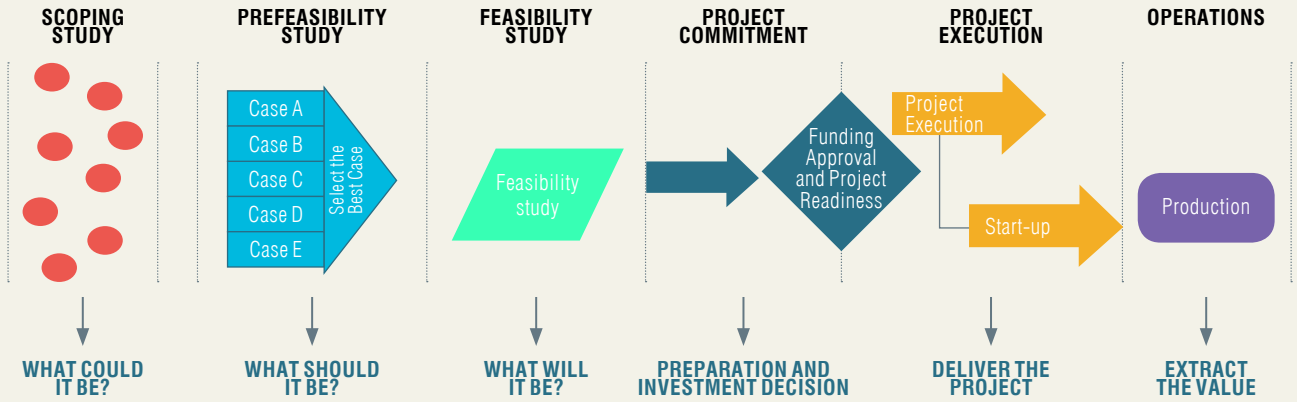
When the project proponent's focus is only on increasing precision in each step, it is often a surprise when the project turns out to be 'precisely wrong'. Successful project developers know that the process has more depth than this. It follows a course that develops a business case from concept stage to option selection to definitive design for final approval and implementation. The scoping and prefeasibility stages are where potential development options should be identified and assessed (Figure 1). Just as NASA's 9 steps of commercialisation (Banke, 2010) applies a stage-gated approach to investment decisions in new technology, mining projects also need to follow a stage-gated, fast fail and pivot approach when assessing options, thinking divergently and then convergently in an iterative process of elimination. Sykes, Trench and Hronsky (2015) allude to this convergent and divergent thinking as 'a scientific, hypothesis-testing approach, essentially optimising the ... algorithm' and 'the creative (approach), generating new hypotheses'.

So why is it that the boards of so many small to mid-tier mining companies (and a few majors) focus on relentless project milestone delivery too early in the project process, with so little time and effort applied to risk analysis and option development? Unforeseen risks can cost any timeline or budget far more than the effort required assessing and mitigating these. Missed opportunities can represent orders of magnitude multipliers of project value that add no more cost to the project than the cost of seeking reliable and experienced advice from those who have done it before. A list of common 'mistakes' made in prefeasibility studies was compiled by McCarthy (2014) (Table 2). This list highlights the tendency to prematurely select a sub-optimal mining method and metallurgical process.

Table 1. Range of precision of estimates in most Australian feasibility studies (McCarthy, 2014).

Scoping	Prefeasibility	Definitive feasibility	Detailed engineering (ie operational readiness)
-50% to +30%	-27% to +30%	-20% to +27%	-12% to +20%

Figure 1. The stages in new mine development (McCarthy, 2014).



A need for divergent thinking

Prime Minister Malcolm Turnbull's timely announcement in December 2015 on the 'National Science and Innovation Agenda' sets the scene for divergent thinking (and thus inclusive diversity) to overcome availability heuristics, anchoring bias and groupthink so that we can generate optimal solutions to problems. This article discusses the merits of having a diverse team on mining feasibility studies to minimise risk, maximise value and hopefully come up with transformative, game-changing new ideas.

What do clients want?

A white paper on client expectations (Flett et al, 2012) highlights the need for consultants to deliver high quality, fast, value-for-money and value-adding solutions to problems. Expectations of clients today are much higher than they were pre-global financial crisis as competition between consultants has grown for limited project work. There is a need for a greater focus on creative, multidisciplinary collaborations that tap into the collective diversity of the group. This diversity is not just in technical and experiential skill sets but also in personality type (eg Deloitte's Business Chemistry: driver, guardian, pioneer and integrator) to ensure all aspects of the project are covered by different people's strengths (ie for relationship management, project management/governance, technical expertise, devil's advocate and outside-the-box thinking).

Consultants must walk in their client's shoes, understand their needs and focus on what's important. If consultants do this well, it's a win-win for all as the client is happy, will use the consultant again and provide valuable testimonials. The more work a consultancy gets, the more opportunity there is to leverage a growing body of knowledge (eg benchmark cost and productivity data) and potentially develop that into a subscription based service accessible through a webpage.

Table 2. Main sources of error in feasibility studies compared to actual performance in operations. (McCarthy, 2014).

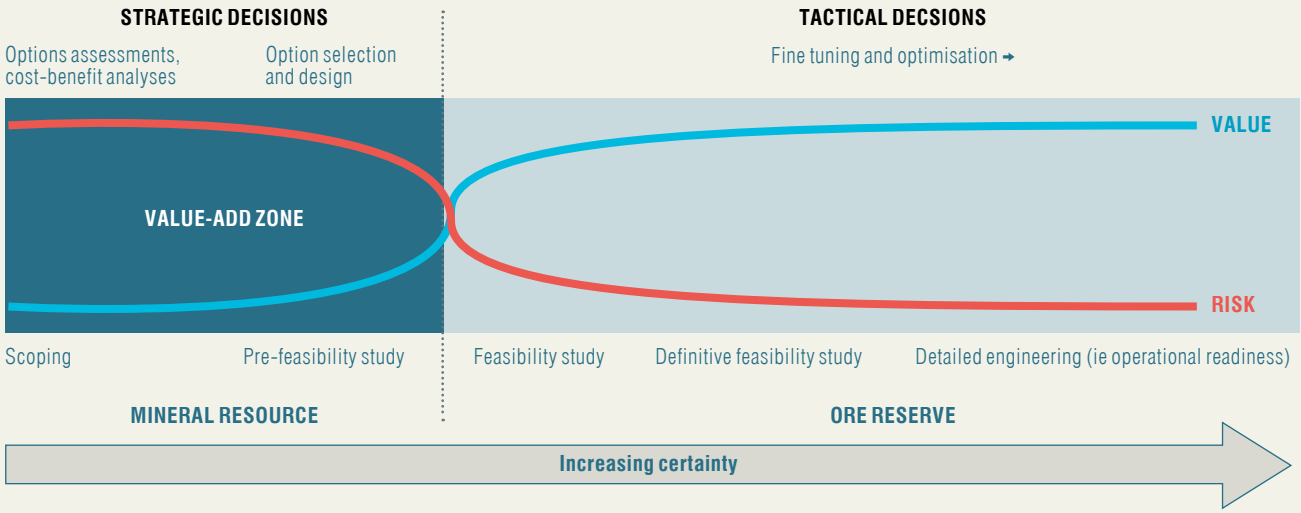
Area of problem	Frequency (%)
Mine design and scheduling	32
Geology, resource and reserve estimation	17
Metallurgical test work, sampling and scale up	15
Process plant equipment design and selection	12
Geotechnical analysis	9
Cost estimation	7
Hydrology	4
Mining equipment selection	4

Expectations of clients today are much higher than they were pre-global financial crisis.

Value-adding has the greatest impact at the scoping and pre-feasibility stage

Figure 2 shows a project's decreasing risk and increasing value as the project matures through the feasibility stages. This is due to access to increasingly precise information and detailed analysis, providing greater certainty. The scoping and prefeasibility stages are the most important stages of a new mine development because decisions made at this point determine, to a large degree, the project's destiny. This is a good time to consult with innovation experts and research groups to see if any transformational ideas are of relevance. Failure to generate the best solution in the PFS stage can result in failure of the project due to the following reasons as

Figure 2. The risk-reward inverse relationship for a new mine development.



given by McCarthy (2014):

- the capital cost is higher than expected
- the operating cost is higher than expected
- the recovered grade is lower than expected
- sales revenue is lower than expected
- it takes longer to build and ramp up than expected
- initial performance cannot be sustained, though it may take several years for the failure to become evident.

McCarthy (2014) provides the following analysis on studies from the 1970s to the late 1990s comparing expected versus actual performance of new mines:

- "In the 1970s, a study for the World Bank showed that in the first year of operation after commissioning, 60 per cent of the mines and 70 per cent of the treatment plants surveyed achieved a production rate of less than 70 per cent of design capacity.
- In the 1980s, a study of 35 Australian gold mines found that 68 per cent failed to deliver the planned head grade
- A similar review of nearly 50 North American projects showed that only 10 per cent achieved their commercial aims with 38 per cent failing within about one year
- A study of the start-up performance of nine Australian underground base metal mines found that only 50 per cent achieved design throughput by Year 3 and 25 per cent never achieved it at all.
- A US study comparing the final feasibility study production rate with the average sustained production rate from sixty steeply-dipping tabular deposits found that 35 per cent of the mines did not achieve their planned production rate."

More recent studies (Harris et al, 2014; Burns and Dogget 2004) reinforce the learnings from pre-2000 studies described above.

Value-adding through innovative solutions

In order to facilitate divergent thinking and innovative solutions in mining (preferably up front before the cap-ex is spent) it's crucial to ensure the client and consultants have the right systems and culture in place to make it happen. The seven key practices of innovation (Goldsworthy and Atkins, 2015) (Table 3) show that a culturally inclusive organisation that communicates two-ways clearly, openly and regularly is crucial to the ability of a company to be collaborative and creatively disruptive.

The link between inclusive diversity and innovation: the need to address subconscious bias

Thomas (2015) quotes recent US research findings stating it's a myth that companies are meritocracies. Everyone has unconscious bias. Since 2012, many studies have been undertaken in the US by Yale (2012), Harvard Business School, Wharton and MIT Sloan (2014) finding discrimination against female science, technology, engineering and mathematics (STEM) professionals was widespread, such that their voice is not heard and a large body of knowledge and expertise is wasted. It's clear from this research and anecdotal evidence in Australia that more needs to be done to improve the retention of women and minorities in STEM roles. This will allow us to make the most of the divergent thinking, and maximise Australia's innovativeness and global competitiveness. The following research recommendations are applicable to consultants (Thomas, 2015):

- STEM professionals promoted to manager roles should be trained to understand subconscious bias and to have the soft skills necessary to manage people fairly and inclusively.
- Avoid reliance on self-evaluations as women underestimate their capabilities and men overestimate their capabilities.
- Don't emphasise 'face time' (ie long office hours) as this marginalises those with caring responsibilities (eg parents).
- Create a collaborative environment. Stanford research (2007) shows women are more likely to dislike competitive environments and are more likely to select out of them, regardless of their

ability. Sheryl Sandberg (2015) states that women are perceived negatively for being too assertive, so it's tougher for women to succeed in a highly aggressive environment.

- Offer flexible working arrangements to enable work-life balance and promote creativity.

The importance of soft skills

Kay and Shipman (2014) recently collated evidence of a consistent confidence gap between men and women, including work by US researchers stating that many men use 'external attribution' (blaming difficulties on something other than themselves) to stay confident. On the other hand 'internal attribution' (blaming one's self and feeling inadequate) and perfectionism are confidence killers, often a problem for women. External attribution tendencies mixed with testosterone are shown to lead to excessive risk-taking behaviour in men. Internal attribution tendencies and oestrogen fuelled horizon-scanning tendencies lead to risk-aversion in women. It takes emotional intelligence to guide a team with such differences (as well as different personality types, learning styles and backgrounds) through the divergent thinking and convergent solution-finding process, but it should lead to decisive action with well-managed and understood risks. It is therefore vital for inclusive diversity to be a strategic imperative.

Don't be afraid of honesty when evaluating project risks. Always question your assumptions.

Conclusion: diversity imperative in consulting and mine study teams

The upfront, risky stage of a new project is where the most value can be added, because the risk-reward premium is highest. Empowering project feasibility and/or project design teams to be diverse and think divergently ensures:

- value is not destroyed (ie project achieves expected return and milestones)
- creative disruption opportunities are embraced (eg using new mining methods, equipment and/or treatment processes)
- social justice prevails (ie safer mines and communities)
- sustainable practices are promoted (eg not wasting precious resources through sterilisation due to poor design and/or operational practices).

Industry standards and community expectations are rising when it comes to corporate social responsibility. A diverse team for feasibility studies (and operations) is more able to meet these rising expectations.

To ensure the success of your feasibility study, set up these ground rules first (van Olden, 2015):

- When a business concept has been identified, select a broad team to collectively identify the study scope, risks and opportunities. Guard against group-think, subconscious bias and blind spots by using a professional independent facilitator.
- Don't be afraid of honesty when evaluating project risks. Always question your assumptions.
- Be explicit on the objectives.
- Be clear on evaluation methodologies, which should be determined consultatively upfront. Set time and budget limits and beware of 'analysis paralysis'.
- A study should be about learning. With learning, perspective can change. Install appropriate feedback loops (ie a stage-gated approach) to stay focussed on measures of success and make the right decisions at the right times (ie fast fail and pivot).
- Close off the study with a clear consensus decision (ie selected option), the risks to be managed and the communication required with all stakeholders.

It's a tough environment in the minerals consulting space as clients and consultancies prune their businesses to survive the lean times. Tough decisions

Table 3. Seven key practices of innovation (Goldsworthy and Atkins, 2015).

No	Key practice	Description
1	Think long-term	Provide a clear, well-articulated connection between project success criteria and value to the company (linked to business strategic imperatives).
2	Appoint connector project managers	Select project managers who are capable of engaging with all key stakeholders. They need to be technical translators, communicators, relationship managers and networkers making connections across functional and organisational boundaries.
3	Envision the desired future state	People working on the solution must have a clear understanding of the problem and what success looks like.
4	Leverage human capital	Nurture long-term, trusting relationships with partner organisations that have the potential to be 'solution providers' in the future. They could be suppliers, clients, universities or specialist/professional consulting firms.
5	Be open	Maximise honest, two-way communication between solution providers and end users.
6	Be consultative and communicate often	Ensure regular communication to those not directly involved so they understand and are supportive of the outcomes when they need to be implemented. Even the best project managers will not have experience across the whole value-chain of the company and will therefore have blind spots.
7	Implement through change management	Finding a solution is half the problem. Implementing the solution requires change management and a risk-based approach. This requires clear technical and management oversight, sufficient resources, allocation of appropriate authorities and accountabilities to achieve positive net impact.

are being made about teams that will have lasting consequences. The consultancy teams that survive the tough times will thrive as the cycle turns, because they have become more creative, agile and lean with the ability to support clients who have lost key capability during their own survival mode. B

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