The Pre-Feasibility Study – Big Choices, Little Time

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ABSTRACT

As of 1 December 2014, the 2012 edition of the JORC Code requires Ore Reserves to be defined by studies at the pre-feasibility or feasibility level. This paper examines how the pathway for most mining developments is determined in the Pre-Feasibility Study and how a trade-off must be made between the need to make the best decision, the constraints of limited time and resources, and the level of the project's accuracy and uncertainty in terms of value. Issues considered include framing the scope of the study, planning for robust decision-making and ensuring effective communication between the diverse disciplines within the team.

An inherent conflict exists between the immediate value added to a mining business from an increase in ore reserves resulting from a 'quick' Pre-Feasibility Study and the long-term value of pursuing a development strategy based on proper investigation and evaluation of the options. Recognition and resolution of this conflict is necessary if a project is to progress into future development stages, both in a timely manner and with the optimal development alternative and strategy.

The challenge for project developers and those conducting the Pre-Feasibility Study is to understand what the key deliverables are (ie an Ore Reserve statement, option selection, business evaluation, forward work plan or risks) and how to follow good practice to ensure that these deliver value.

INTRODUCTION – THE PURPOSE OF A PRE-FEASIBILITY STUDY

Pre-feasibility or preliminary feasibility?

The terms Pre-feasibility Study and Preliminary Feasibility Study are generally used interchangeably. This usage is confirmed in the definition provided by the Canadian Institute for Mining, Metallurgy and Petroleum (CIM, 2014). The JORC Code also adopts the same definition:

> *A Preliminary Feasibility Study (Pre-Feasibility Study) is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where the preferred mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumption of the Modifying Factors and the evaluation of any other relevant factors which are sufficient for a Competent Person, acting reasonably, to determine if all or part of the Mineral Resources may be converted to an Ore Reserve at the time of reporting. A Pre-Feasibility Study is at a lower confidence level than a Feasibility Study.* (JORC, 2012)

An alternative view is to consider them as terms that have subtly different meanings and can in fact be two separate studies (or stages within a study), with the final or definitive feasibility study being the last in the sequence prior to an investment decision:

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- the Pre-Feasibility Study is not a study of a project's feasibility as such, but an options evaluation study that is conducted by necessity prior to the feasibility study in order to choose the development alternative that is to be assessed for feasibility
- the Preliminary Feasibility Study is a feasibility study that is preliminary and not yet finalised, but may be sufficient to justify additional effort on more data collection, development alternative optionality, detailed scope definition, preparation of an environment impact study and possibly the commencement of detailed engineering, long lead item procurement and preliminary site works
- the feasibility study (often called definitive, detailed, final or bankable) is a finalised study into the feasibility of a project on which an investment decision can be based.

While it could be argued that this is a semantic difference, it highlights the distinct difference in purpose, which can be a source of confusion for those planning and conducting a Pre-Feasibility Study if not clearly understood.

This difference in purpose has long been recognised by BHP Billiton, which has eschewed the traditional naming of study phases to use a nomenclature that maintains a focus on the purpose of each phase. Instead of using the terms 'concept', 'pre-feasibility' and 'feasibility' study, BHP Billiton's study phases are called 'identification', 'selection' and 'definition' (Bueno Da Silva, Gillespie and Buckeridge, 2012).

In practice, pre-feasibility studies usually perform two functions:

1. the selection of the go-forward development alternative (or at least it should)
2. a preliminary assessment of a project's viability to the extent necessary to justify the expenditure of the next phase.

Since 1 December 2014, an additional outcome from this preliminary assessment of a project's feasibility is the reporting of Ore Reserves. The reporting of additional Ore Reserves can create significant value for shareholders through a substantial increase in the perceived/perceivable value of the assets it controls. The challenge in this is that it creates pressure on those conducting the Pre-Feasibility Study to complete it within as short a time frame as possible. If a company's management is either unwilling or unable to provide time and resources to complete both the options study and a preliminary assessment of feasibility, those planning and managing the Pre-Feasibility Study may be driven to reduce the number of options (or development alternatives as they are referred to in this paper) considered, possibly to just one. If the study is not a 'comprehensive study of a range of options', it does not fit within the definition provided in the JORC Code.

Outside of the definitions in the JORC Code and the CIM Definition Standards, there is quite a diversity of nomenclature used, and there is a lack of clarity as to what is required of a Pre-Feasibility Study. A recent paper by Wittig (2014) seeks to clarify study naming conventions and also proposes that a Pre-Feasibility Study consists of two distinct stages: 'opportunity framing' and 'go-forward alternative'.

Most of the major mining companies have their own defined standards for studies. A 2012 report by Bueno Da Silva, Gillespie and Buckeridge (2012) compares terminology in the coal industry, finding that there is a reasonable alignment of study phase activities, if not naming.

A paper by Logan, Grant and Pratt (2006) detailing Newcrest's process for project development provides a good reference for how major mining companies typically approach studies in the context of project development. It is clear that by the end of the Pre-Feasibility Study, a project development alternative is selected and the project can then be assessed in detail for viability.

While the outputs of each study may be identified, there is less clarity on how a Pre-Feasibility Study should meet the definition of being 'a comprehensive study of a range of options'. Commonly accepted leading industry practice for the sequence of key activities undertaken during a Pre-Feasibility Study is shown in Figure 1.

As shown, the sequence is to:

- generate a spectrum of development alternatives from the initial concept
- select a go-forward alternative
- evaluate the selected alternative against criteria appropriate for the business

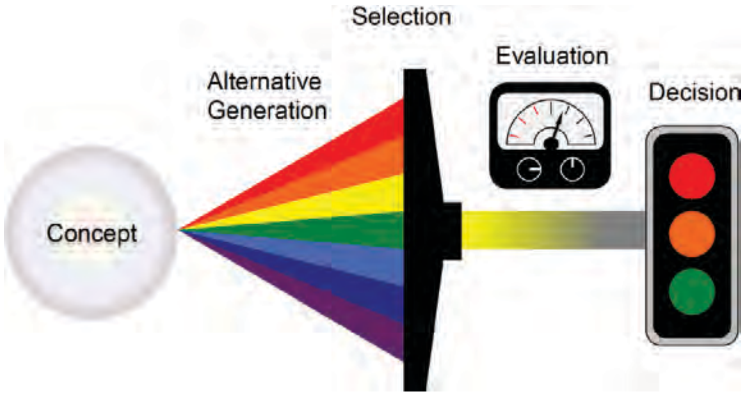

FIG 1 – Pre-Feasibility Study process current practice.

- decide whether to progress the project to the next stage, cease development (or put it on hold) or return the project for further study.

DEVELOPMENT ALTERNATIVE GENERATION

It is generally accepted that a Pre-Feasibility Study will involve studies of a range of development alternatives to determine those that are technically feasible and economically viable and then the selection of none or one alternative to take forward into a feasibility study (Mackenzie and Cusworth, 2007; White and Harrington, 2014). This is where the Pre-Feasibility Study should be inextricably linked to the scoping or order of magnitude study, which should ideally have explored a wider range of development alternatives and assessed those that are most likely to have the potential to be economic and worthy of further study.

To avoid terminology confusion, a development alternative is considered to be a set of unit processes or operations describing the entire project definition, from mine to market, over the life cycle of the project. An option or options are considered to occur within a development alternative.

There is limited literature on the generation of development alternatives for resource development at either a scoping study or Pre-Feasibility Study level. The majority of literature is focused on option analysis around one or two of the unit processes, such as the mining method, production rate and/or processing route alternatives (Whincup, 2010; Rashidi-Nejad, Suorineni and Asi, 2014). However, together with other variables such as selectivity, stockpiling, blending, tailings disposal, waste rock generation and disposal, these are 'intertwined in the sense that none of them can be determined in isolation from the others' (Camus, 2002). Only a limited number of options for specific design parameters within a development alternative are usually considered.

The holistic or systems perspective of the generation and assessment of development alternatives are often believed to be either too costly, too time intensive and/or too complex and challenging (Hall, 2014). The regulatory timelines and processes for environmental approvals, in addition to other project development imperatives, drive a relatively comprehensive definition of the project before the assessment work of a Pre-Feasibility Study is complete (Robinson, 2008). In recent times, infrastructure costs have accounted for more than 75 per cent of project capital costs, making them a significant driver of net present value (NPV) that should be included as a critical component in any development alternative (Curry, Keith and Jackson, 2013). Generating too few alternatives risks failing to identify significant value-creating alternatives, which can lead to a suboptimal project. On the other hand, having too many alternatives leads to an unmanageable and confusing study. The alternatives should be sufficiently differentiated, and those that have minimal impact should be included as options within an alternative rather than as an alternative itself.

In a recent study of uncertainty management across 20 mining project studies, Kuhn and Visser found that brainstorming and document reviews were the most common technique used to identify potential risks (Kuhn and Visser, 2014). However, they noted that the focus was on adverse consequences impacting on the projects, meaning that opportunities for improvement were neglected or totally ignored.

The ability to enable project members to share a common view or 'sense making', especially of the interdependencies, is a common problem in many projects and one of the key elements in projects not meeting expectations (Berggren, Jarkvik and Soderlund, 2008; Williams, 2010; Rolstadås *et al*, 2015). A number of methodologies exist to generate development alternatives and options, including:

- SUSOP® is an approach for the integration of sustainable development principles into the design and operation of industrial processes across financial, environmental and social outcomes (Corder, McLellan and Green, 2012; Corder *et al,* 2012; McLennan and Corder, 2013)
- life cycle assessment methodology can be used to identify the most important stages and highest potential for impacts within a life cycle and has been used within the industry from an environmental perspective (Azapagic, 2004; Durucan, Korre and Munoz-Melendez, 2006)
- morphological box analysis (Jones *et al*, 2009)
- analysis of interconnected decision areas (Luckman, 1967)
- the Delphi method and TRIZ (Fresner *et al*, 2010).

Whichever option generation method is selected, it ultimately comes down to the resourcefulness, creativity and business perceptiveness of the multidisciplinary team, which must be cognisant of issues such as anchoring, recency, vividness, optimism bias, strategic misrepresentation and group biases (Camus, 2002; Flyvbjerg, 2008; Bratvold and Begg, 2010). This is time consuming when done properly, but given the opportunity cost and near irreversible decision once in construction, the value is high.

Uncertainty, development alternatives and robustness

There are two sets of uncertainty that developers of mineral projects need to consider: internal and external. Internal uncertainties are those where the project owner has the ability to reduce and/or manage uncertainty. These include orebody knowledge and the associated processing performance, environmental and social impacts of the development alternative. External uncertainties are those that are predominately outside the control or management of the project owner, such as commodity prices, exchange rates, government regulations and political factors.

Current common approaches to the assessment of these uncertainties tend to focus on orebody grade uncertainty (internal), sensitivity analysis (internal or external) or Monte Carlo simulations (internal or external) and are only static assessments of a single development alternative. They do not address the opportunity to be dynamic in response to potential scenarios, either at the development alternative generation stage or within an alternative. The generation and evaluation of development alternatives to enable contrasts under uncertainty is critical and is arguably the most important step in project success (Bratvold and Begg, 2010; Vann *et al*, 2012).

Scenario-based planning in the context of mineral project evaluation is aimed at understanding and then developing plans in the face of uncertainties across the following three key aspects (van der Heijden, 2005; Walker, Haasnoot and Kwakke, 2013):

- resistance – planning for a future situation
- static robustness – aimed at reducing vulnerability across the largest range of conditions
- dynamic robustness – enabling the ability to change the plant over time in case conditions change.

Ideally, the process is an iterative one where there is a feedback loop where development alternatives are revised to cater for the uncertainties to make a more robust project. There are many qualitative and quantitative styles of scenario-based planning and many methods of developing the scenarios themselves. Two styles of scenario-based planning that are applicable to a project at the pre-feasibility stage are assumption-based planning (ABP) and robust decision-making (RDM).

RDM is an approach used to produce a static, robust plan by using multiple views of the future to support a thorough investigation of modelling results (Walker, Haasnoot and Kwakke, 2013). The robust plan performs well enough across a broad range of plausible futures but may not perform optimally in any single future. However, it avoids most situations where the plan would fail to meet its goal and highlights the conditions where it may fail. The scenario-based evaluation of mineral projects outlined by Vann *et al* (2012) is an example of an RDM approach.

ABP is primarily a post-planning tool that was originally developed for the military. It focuses on identifying the assumptions upon which the success of the plan depends and generates three things:

1. signposts – to monitor assumptions that are most likely to generate surprises

2. shaping actions – to shore up uncertain assumptions
3. hedging actions – to be better prepared if assumptions fail.

In both approaches, the outcome is an understanding of the assumptions and greater insight into the robustness of the development alternatives that can guide where assumptions need to be further investigated and whether to progress the project to the next stage, review further development alternatives or stall the project.

Scenario-based planning and analysis requires resources (time, money and effort) to undertake the work and implement the actions. In the context of project evaluation, it appears to be most applicable within a Pre-Feasibility Study upon the final selection of the development alternatives, and in a feasibility study as a stress test/conformation step prior to the investment decision. Thus, those involved in planning for a Pre-Feasibility Study should allow sufficient resources for scenario-based planning to be undertaken. However, there is no benefit if the organisation or project team are very defensive or the decision as to the final development alternative is locked in and any outcomes will not change the plan.

SELECTION AND EVALUATION

To make a selection between development alternatives, there must be some rankable measure of value established with reference to the corporate goals of the mining business (or businesses in the case of joint ventures). Typically, this includes an accounting measure derived from a discounted cash flow such as NPV, internal rate of return and capital efficiency ratio as well as measures such as cash operating cost per unit.

A limitation associated with a pure deterministic accounting approach is that it does not necessarily take into account the real uncertainties that are inherent in the assumptions of inputs, such as the Modifying Factors for a development alternative, the value of flexibility or dynamic robustness or the range of 'external' scenarios that may have a considerable impact on the outcome of pursuing the selected development alternative.

Real options analysis and valuation (ROA/ROV) is one method of incorporating the value of dynamic robustness or flexibility within a development alternative. Traditionally, ROA was focused on external uncertainties such as commodity prices, but, more recently, it has begun to incorporate engineering flexibility, technology uncertainties and technical risks (Botin *et al*, 2012).

Considerations such as robustness (under uncertainty), socio-economic/environmental risks, fit with business strategy, portfolio management and the availability of capital/finance are important in the broader evaluation of development alternatives. However, combining the full range of these considerations into a single measurement of value for ranking of alternatives is not a simple task. The SUSOP® approach (Corder *et al*, 2012) seeks to incorporate sustainability issues into a broader measure of value, and attempts have been made to integrate this with economic enterprise optimisation (Whittle, 2013).

Hall (2014) highlights the difference between the evaluation of discrete development alternatives and evaluation and optimisation within a continuum of alternatives. The 'hill of value' concept is presented in a three-dimensional space with mining rate and cut-off grades as independent variables and value (NPV presumably) as the dependent variable. This approach becomes challenging as more dimensions are added and an increasingly complex mixture of discrete and continuous options and constraints are considered.

Accuracy

Caution is advised when stating the accuracy of a particular study as a whole. When making a statement to this effect, it implies that the accuracy expressed is for the whole of project value measurement, not just capital cost.

For example, if using a discounted cash flow measure of value, the capital cost is only one of many estimated components that will influence value. Geological modelling, operating cost, closure costs, mining rate, dilution, plant throughput, recovery, commodity prices, taxation regime and perhaps socio-political risk are all estimated to varying degrees. Thus, accuracy of any measure of value is a function of the accuracy of the inputs into that measure.

It is quite erroneous to imply that if the capital cost has been estimated to some determined level of accuracy, the overall 'value' assessment of the project has been assessed to the same level.

Cost estimates classification

AACE International publishes guidelines on the classification of estimates within a suite of documentation called the Total Cost Management Framework. The relevant guidelines for estimate classification in the minerals industry are:

- Recommended Practice 17R-97: Cost Estimate Classification System (AACE International, 2011)
- Recommended Practice 47R-11: Cost Estimate Classification System – As Applied in the Mining and Minerals Processing Industries (AACE International, 2012).

Recommended Practice 17R-97 provides a generic system for classifying estimates, whereas 47R-11 is an addendum to the generic recommended practice that 'provides guidelines for applying the principles of estimate classification specifically to project estimates in the mining and minerals processing industries'.

These recommended practices define five classes of estimate, ranging from Class 5 (lowest maturity – for conceptual planning) to Class 1 (highest maturity – for fixed-price bids and check estimates).

Recommended Practice 47R-11 provides a definition deliverable maturity matrix that is specific to the mining and minerals processing industry. In this context, it should be noted that the class of estimate is determined by the maturity of the project definition deliverables and not the accuracy *per se*. Recommended Practice 47R-11 was released in 2012 and has been developed to align with Canada's National Instrument 43-101 Standards of Disclosure for Mineral Projects (NI 43-101) and also references other mineral reporting codes such as the JORC Code. The recommended practice states that a Class 4 estimate is the minimum requirement for reporting an economic reserve (in JORC Code terms, 'Proven' or 'Probable'). A detailed description of a Class 4 estimate is provided in Table 2b in 47R-11, which is reproduced as Table 1 in this paper.

Although 47R-11 does give an expected accuracy range for each class of estimate, this is a secondary characteristic. The primary characteristic is the maturity level of project definition deliverables. The

TABLE 1

Class 4 estimate detailed description: AACE International RP 47R-11 Table 2b
(AACE International, 2012; permission to republish table granted by AACE International).

Class 4 estimate	
Description: Class 4 estimate is usually carried out using indicated or measured resources defined by drilling confirmation of the mineralised zone(s). A preliminary geological model and detailed mine plan are required, including supporting pit optimisation, geotechnical and hydro-geological studies, etc. The metallurgical test work should determine the probable process flow sheet and approximate material balance, and identify the major equipment. Engineering would comprise at a minimum: general arrangement (GA) drawings, equipment lists for major equipment, nominal plant capacity, block schematics and process flow diagrams (PFDs) for the main process systems. **Degree of project definition deliverables required:** Key deliverable and target status: process flow diagram (PFD) issued for design for plant and detailed mine plan for the mine. One per cent to 15 per cent of full project definition. **End usage:** Class 4 estimates are vitally important to mining investors internationally. A mineral resource cannot be identified as an economic reserve without an estimate of at least this class. They are held to disclosure requirements by the involved securities jurisdictions and are subject to analysis by third party reviewers. The estimates are used for refining and screening of options, analysing technical and economic feasibility and then identifying the preferred option(s) for the final feasibility study (Class 3 estimate) prior to commitment.	**Estimating methods used:** Major equipment costs are based on recent budget prices from vendors based on preliminary requirements. Facility costs are estimated by approximate quantity take-offs from the GA drawings and applying unit cost factors. Earthworks and infrastructure are not well defined in detail but allowances can be set based on preliminary contours for overland piping lengths and overhead electrical power lines, etc. Equipment installation is estimated by a combination of quantity take-offs and unit cost factors based on the available scope definition. The same method also applies to indirect costs (as a percentage of directs). **Expected accuracy range:** Typical accuracy ranges for Class 4 estimates are -15 per cent to -30 per cent on the low side, and +20 per cent to +50 per cent on the high side, depending on the technological, geographical and geological complexity of the project, appropriate reference information, and other risks (after the inclusion of an appropriate contingency determination). The uncertainty varies by work type with moderate ranges applying to structures and plant commodities, wider ranges applying to earthworks and infrastructure and narrower ranges applying to equipment installation. **Alternate estimate names, terms, expressions, synonyms:** Pre-feasibility or preliminary feasibility (per NI 43-101), intermediate economic study estimate, equipment factor estimate.

recommended practice also goes on to clarify that 'the state of technology, availability of applicable reference cost data and many other risks affect the range markedly' (AACE International, 2012).

It is also important when stating an accuracy range to be specific about the confidence limits within which an accuracy range is stated. Common (though not universal) practice is to state an accuracy range between the ten per cent (P10) and 90 per cent (P90) confidence limits and to use the median (P50) of the distribution as the stated estimate amount. This means that the final outcome has a ten per cent likelihood of being less than the lower limit and a 90 per cent likelihood of being less than the upper limit, meaning an 80 per cent likelihood of being within the range.

Figure 2 shows an 'example' of variability of accuracy range. Further discussion within 47R-11 advises that while estimates of each class would be generally expected to produce accuracy ranges that fall within these envelopes, 'the accuracy range is determined through risk analysis of the specific project and is never predetermined' (AACE International, 2012).

In summary, care is advised when making statements about the accuracy of a study without conducting a comprehensive assessment of risk and uncertainty. This is particularly the case for early-stage studies such as a Pre-Feasibility Study, where many different and uncertain factors will have an impact upon the overall accuracy of the measure of value. For a Pre-Feasibility Study, it is important to understand the accuracy/uncertainty of evaluations in the context of both selecting between development alternatives and justifying further expenditure.

Combining evaluation and selection – 'optimisation'

Hall (2014) highlights the difference between the 'typical strategy selection process', where strategic decisions are made and then fed into a 'simple model' for evaluation against corporate goals, and the 'typical strategy optimisation process', where viable alternatives, options and constraints are combined with corporate goals in a 'robust model', which is then used to generate a multidimensional landscape of value from which an optimal alternative can be selected.

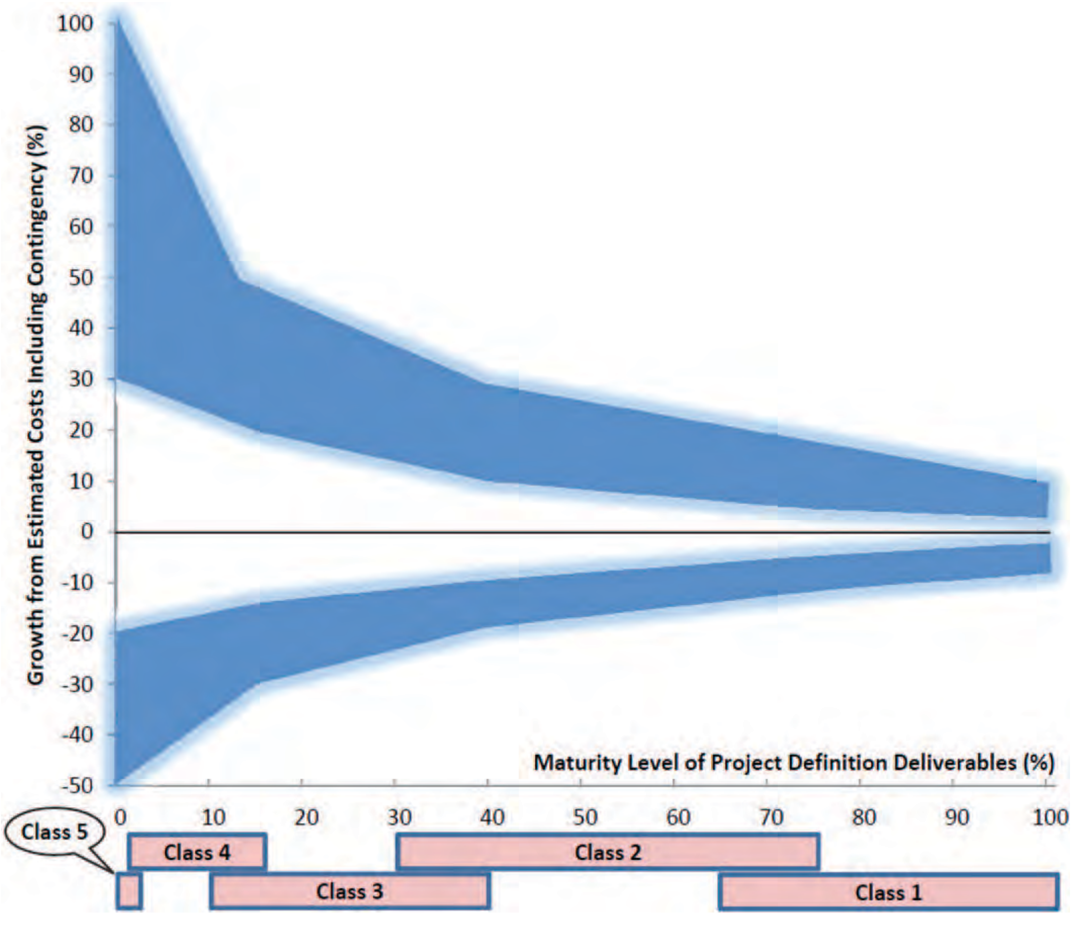

FIG 2 – Example of the variability in accuracy ranges for a mining industry estimate: AACE International RP 47R-11 Figure 1 (AACE International, 2012; permission to republish figure granted by AACE International).

The first of these processes aligns with that shown in Figure 1. The second process is represented in Figure 3, where evaluation and selection are combined. Ideally, if the model can be sufficiently comprehensive, this would remove the need to perform further evaluation prior to the decision to progress to a detailed assessment of project feasibility. In practice, this requires considerable skill and effort to establish an appropriate model and collect the necessary input to ensure that the model is based on the necessary valid data.

In the end, this creative generation of alternatives, the choice of the appropriate measure/s of value and the creation of a robust model for the evaluation of alternatives are all necessary for the effective selection of the preferred go-forward development alternative. Such an approach will likely improve the industry's record of less than 35 per cent of projects meeting business expectations (Curry, Keith and Jackson, 2013).

ORE RESERVE AND VALUATION REPORTING

The definition of an Ore Reserve under the JORC Code is 'the economically mineable part of a Measured and/or Indicated Mineral Resource' that is defined by at least a Pre-feasibility Study including the application of the Modifying Factors, which 'demonstrate at the time of reporting, extraction could reasonably be justified' (JORC, 2012). Together with the purposes and principles of the JORC Code and the advances in project evaluation methodologies, this requirement raises the issues of:

- materiality of current uncertainties of a project
- transparently informing an investor of the robustness
- the time pressures to announce an Ore Reserve and the results of the Pre-Feasibility Study.

As discussed earlier in this paper and as outlined in the JORC Code, a Pre-Feasibility Study requires a comprehensive study of a range of development alternatives where a preferred development alternative could be selected across a range of value measures. From a transparency and materiality perspective, an argument can be made that the Ore Reserves and associated value outcomes should be reported for each of the development alternatives under the selected scenarios. This allows an investor or potential investor to make an informed decision as to the likely robustness of the project and, hence, the risk related to investing. At the very least, the development alternatives considered should be discussed when reporting the outcomes.

However, portraying such information in a simple, digestible manner is not straightforward, especially when the extensive array of Modifying Factors and associated confidences are considered for each development alternative and selected scenario. As pointed out by Noppe (2014), it is possible that a lower level of confidence in just one of the key Modifying Factors may result in a reclassification of the category for all or part of the Mineral Resource. This requires an in-depth understanding of the materiality of the Modifying Factors and any interdependencies that go beyond standard sensitivity analysis.

It becomes more complex when the Mineral Resource and/or Modifying Factors have been assessed stochastically, such as the impact of Ore Reserve estimates with price uncertainty (Evatt, Soltan and Johnson, 2012), mine plan selection under price, grade and exchange rate uncertainty

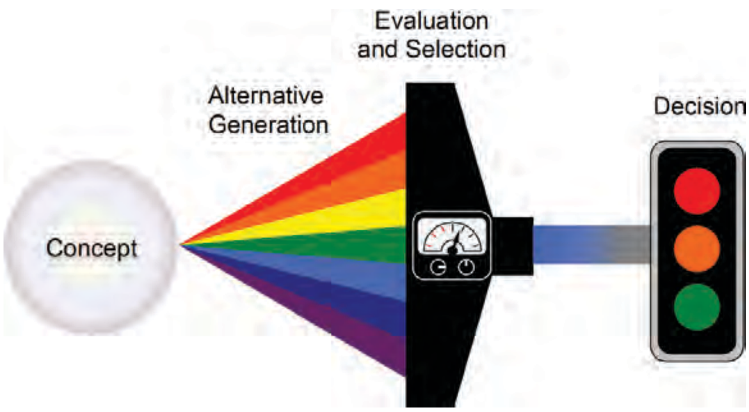

FIG 3 – Pre-Feasibility Study process with combined evaluation and selection.

(Dimitrakopoulos and Abdel Sabour, 2007), scenario-based project evaluation (Vann *et al*, 2012) and operating cost uncertainty (Dehghani, 2012; Dehghani, Ataee-pour and Akbar, 2014).

Time often becomes a driving force through the scoping, pre-feasibility and feasibility stages. The pre-feasibility stage is generally acknowledged as the largest value creation phase of mineral project development both in absolute and relative terms as it is the first sight of an Ore Reserve (Mackenzie and Cusworth, 2007; JORC, 2012). Thus, the pressure exists to complete the studies as soon as possible in order to increase shareholder value. This results in the setting of investor and market expectations and the project team focusing on a perceived low-risk standard approach. The ability to incorporate stress tests of the alternative, a study of options and the potential to extract maximum value through various development alternatives and/or the incorporation of flexibility is limited.

The compromise required to fit within time constraints is often that the alternative generation and selection steps within a Pre-Feasibility Study are reduced to a small range of options trade-offs within a predetermined strategy, as shown in Figure 4.

While this may accelerate an increase in value through earlier reporting of Ore Reserves, it has the potential to limit the consideration of higher-value alternatives and thus compromise longer-term value. The impact may become apparent later in the development phase when strategic choices are revisited, revised and require rework, leading to delays and further expense. Alternatively, the impact may not become apparent and remain as a missed opportunity for further value enhancement.

A review of a number of public disclosures of the outcomes of pre-feasibility studies released over the past 12–18 months indicates that the overwhelming majority report deterministic outcomes for only one development scenario, invariably to a precision that belies the uncertainty around key inputs and Modifying Factors, despite the disclaimers and clarifications. Reporting under NI 43-101 could be considered more transparent due to the detail within the published Technical Report; however, this requires careful reading and analysis of the methods, assumptions and outcomes and usually focuses on sensitivity analysis. Only rarely is there any mention of undertaking or the outcomes of the consideration of development alternatives.

CONCLUSION

Pre-feasibility studies are now required to support the reporting of Ore Reserves under the JORC Code. The definition of a Pre-Feasibility Study provided in the code is that it is a 'comprehensive study into a range of options for the technical and economic viability of a mineral project' (JORC, 2012). In practice, the requirement to undertake a Pre-Feasibility Study in support of an Ore Reserve statement creates time pressure on those undertaking the study, which may reduce the comprehensiveness of the study of options. This has the potential to leave significant potential value unrealised.

It may be appropriate to separately define the terms 'Pre-Feasibility Study' and 'Preliminary Feasibility Study'. The declaration of Ore Reserves might then require some form of feasibility study, either preliminary or final/definitive, which may or may not be based on an optimised development alternative. The sequence of studies could then be adjusted to suit the needs of the project's owner, perhaps with an initial preliminary feasibility study to establish the Ore Reserve, followed by a Pre-Feasibility Study to choose the development alternative and then a final feasibility study to

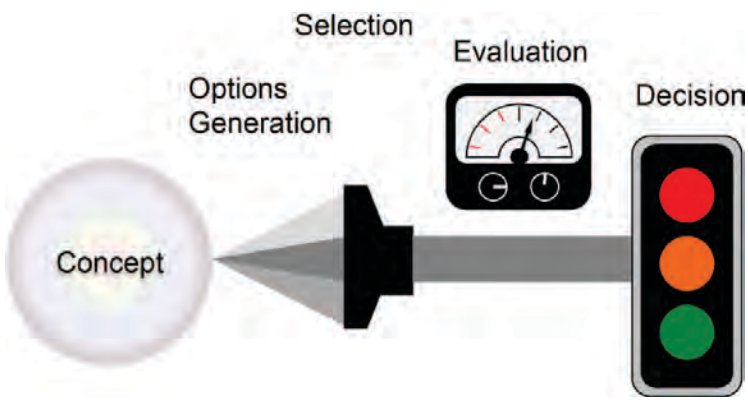

FIG 4 – Pre-Feasibility Study process compromised by time constraints.

define the project to the level necessary to achieve corporate approval and funding. This would separate the long-term maximisation of value through strategic optimisation from the initial creation of value through Ore Reserve reporting and diminish the need to compromise between the two.

The creative generation of alternatives, the choice of the appropriate measure/s of value and the creation of a robust model for the evaluation of alternatives are all necessary for the effective selection of the preferred go-forward development alternative but are often seen as too complex, costly or time consuming.

The development of mineral projects is generally undertaken with a high degree of risk and uncertainty. Good practice requires that these risks and uncertainties be understood, assessed and considered when selecting development alternatives and reporting on the technical and economic viability of projects. The impact of choices is significant and the time is often too little, with the results reflected in the industry's questionable track record of delivering against expectations.

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