THE ROLE OF FEASIBILITY STUDIES IN MINING VENTURES

Bryan Nethery

VP Design Build, AMEC Mining and Metals

PRESENTED

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1.0 THE ROLE OF FEASIBILITY STUDIES IN MINING VENTURES

1.1 Introduction

The feasibility study is a fundamental and key part of the process of development of mining projects. It has a dual role:

- To define the project, its scope, quality, cost and schedule;
- To provide the basis for changes in ownership, financing and other aspects related to the legal condition of the property and project.

A feasibility study is usually undertaken when an Owner believes that a mining project is sufficiently well-advanced to allow a complete assessment of its technical and economic viability. The feasibility study should define the project, its technical nature, reserves, costs, schedule, economics, and risks, and is used to provide the basis for moving forward into financing, design and construction and commercial production. It should mark the end of the exploration phase; if its results are "positive", it often provides the trigger for vesting of interests, investment requirements, ownership changes, etc.

A modern mining project is a complex undertaking, requiring in-depth analysis of geology, application of sophisticated mathematical techniques, computer modeling, process definition through extensive testwork, planning of complex mining, programs, ultimately all being brought together to provide cost estimates and a financial model to predict the project cash flows, NPV, and IRR.

Feasibility studies are only as good as the level and quality of effort applied. Their recent history has been problematic, with some notable failures where large investments have been written off and banks and financiers have taken large losses. These problems have included:

- Capital costs much higher than anticipated
- Ore reserves of lower grade and/or much smaller than predicted
- Poor process performance (recovery, operating time, operability)
- Operating costs higher than estimated.

Projects are inherently risky, but is this risk being properly recognized in the feasibility studies carried out today? In Canada, National Instrument 43-101 is an attempt to improve the quality of information provided to the public and improve confidence in the evaluation and reporting of reserves and ultimately economics to the investing public.

43-101 Definition

"feasibility study" means a comprehensive study of a deposit in which all geological, engineering, operating, economic and other relevant factors are considered in sufficient detail that it could reasonably serve as the basis for a final decision by a financial institution to finance the development of the deposit for mineral production.

This definition raises some interesting issues, a “comprehensive study” considering all relevant factors and in sufficient detail, raises the question, according to what objective measure and to satisfy whom? We understand this in the context of the feasibility study providing a reasonable basis for a financial institution to decide to finance the development. Such decisions are made in the context of the review of the feasibility study by, as a lawyer might say, those qualified and skilled in the practice of the art. This paper will review the context of the feasibility study in the project development cycle, the practice and pitfalls of feasibility studies, issues around resources and reserves, cost estimation, and the function of feasibility studies in mining agreements.

1.2 Context, the Project Development Cycle

The project development cycle is the sequence of activities from discovery of a mining property, through development and production to closure. The following are the key phases of the life cycle of a successful mining project.

- Exploration phase
- Project discovery
- Project resource definition and scoping studies
- Prefeasibility studies
- Feasibility study
- Project financing
- Project development
- Project operations
- Closure and reclamation.

The Junior mining companies dominate exploration and discovery of ore deposits. These companies are typically single purpose groups of exploration geologists and promoters and companies are usually publicly funded vehicles; dedicated to finding and delineating mineral deposits for the purpose of realizing capital gains on discovery of promising deposits.

For the purposes of this discussion, we will focus on the discovery and development of mining projects with a capital cost greater than $50 million, and on the contractual framework and relationships that must be developed between the various parties to bring the project from discovery through feasibility to commercial production.

The order of activities in the initial phases of project development can vary dramatically depending on a number of project specific factors such as:

- The type of resource discovered, i.e., whether it is an open pit or an underground mine deposit
- The location of the project, i.e., remoteness, country politics, infrastructure, legal framework
- The financial and organizational capacity of the mining company discovering the project, i.e., a junior mining company, a mid-tier company, and a major will necessarily have to look to different sources for funding the project, and will have to rely on outside expertise to a greater or lesser degree.

It is the last point that is probably most critical to this discussion, as the junior mining companies have made the majority of new mining discoveries in the last forty years. These Juniors are typically single purpose entities with limited capitalization, and as their sole purpose is usually grassroots exploration for mining projects, geologists most frequently manage them. The juniors prefer to and will attempt to raise capital to fund each step of the project development. Typically, as the project moves toward feasibility or on completion of the feasibility the junior must find sufficient capital to fund the design, procurement, construction, startup and initial operation of the project. This paper is focused on this dynamic of project development.

1.3 Phases of the Mining Project

The various phases of the mining project are fundamental to understanding the role of the feasibility study. The following is a discussion of these phases in the life cycle of a mining project.

1.3.1 Project Discovery

Project discovery is the beginning of the process of development of a mine. For a thousand discoveries, only a few projects become mines. This is the true exploration phase where teams of geologists search for mineral deposits using their arsenal of exploration technology. The typical sequence of events might be as follows.

- Exploration using field reconnaissance techniques
- Air borne geophysics, follow-up with ground geophysics
- Geochemistry
- Field geology, mapping, surface sampling, etc.
- Identification/discovery and acquisition of property rights.

1.3.2 Property Exploration & Resource Definition

This phase includes the delineation of the mineral deposit and hopefully the ore body. Typically this is the phase when the value of the property increases dramatically and the exploration and definition activity of the Junior attracts the interest of the Major.

- Geophysical delineation, geochemical
- Drilling and identification of a preliminary resource
- Sampling and scoping level metallurgical testwork.

1.3.3 Resource Definition and Scoping Studies

During this phase the mineral deposit is typically being drilled, some sampling is being done and the project team is attempting to define the project configuration. Typical big picture issues being addressed at this time include:

- Open pit vs. underground mine
- Flowsheet
- Product selection and marketing.

The scoping study should be used to guide the exploration and definition of the mineral deposit and decision making on the critical aspects of the project configuration. A project financial model should be set up as soon as possible to direct the various trade off studies on an objective economic basis.

The early evaluation of the project allows trade-off studies between underground and open pit mine concepts that may have a profound effect on the exploration effort, drilling requirements and density, etc. Alternatively, underground mining methods have very significant impact on how much of the geological resource ultimately becomes ore in a reserve.

The selection of the appropriate process flowsheet is likewise critical to project economics. Projects often get going in the wrong direction because the proponents are determined to produce some particular product and don't look at the overall project configuration and economics.

The other critical elements that should also be examined include:

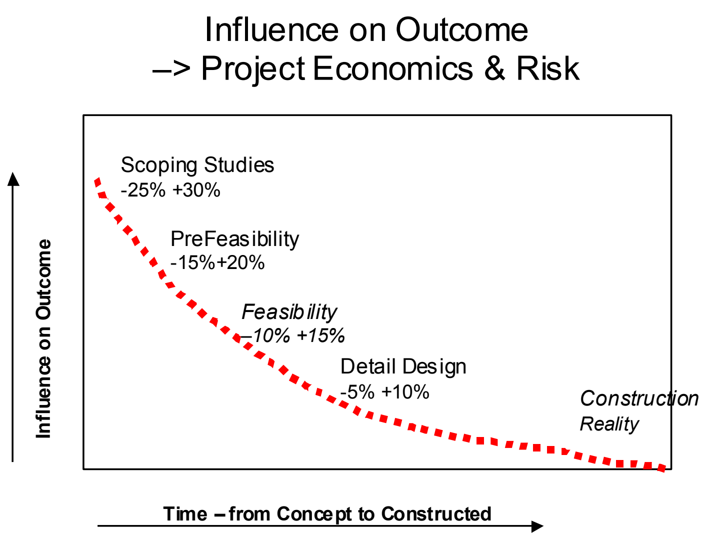
- Power supply options – powerline versus no site and the various types
- Access and transportation options
- Political risks, labour quality and supply
- Environmental issues.

Scoping studies are often performed on an informal basis by the exploration team and management with mixed results. The level of accuracy of the cost estimate is determined by the level of effort expended, and by the quality of information available. A financial model should be developed at this stage of the project and used to guide decisions and assist in trade off studies amongst the various options. Scoping level cost estimates are frequently based on previous projects and on factored estimates. While such cost estimates are essential for examining alternatives and making tradeoffs between capital and operating costs they should not be pushed too far.

Figure 1 shows the expected accuracy of capital cost estimates for the various types of studies prepared for projects and indicates that at the scoping level estimates can be highly uncertain. For this reason if alternatives do not strongly differentiate it is advisable to carry them forward to the Prefeasibility Study and examine these cases in greater detail and at a higher level of accuracy.

The Prefeasibility Study is therefore the next step in project evaluation and optimization and its role is to clearly define the optimal project to carry forward to feasibility.

Figure 1: Expected Accuracy of Cost Estimates



1.3.4 Prefeasiblity Study

The Prefeasibility Study is a more detailed study usually carried out after the broad outlines of the project have been established and a reasonable estimate of the geological resources can be prepared.

Usually considerable additional work is carried out to provide the major inputs to the Prefeasibility Study which include:

- Infill drilling
- Metallurgical sampling
- Metallurgical testwork
- Tailings siting studies, geotechnical investigations
- Access and transportation studies
- Environmental baseline data collection
- Preliminary site costing studies for labour, materials.

Appendix 2 shows the much higher level of effort typically required for a Prefeasibility Study. The industry practice associated with the level of effort in the Prefeasibility Study can vary widely. CIMVal provides the following definition of Prefeasibility.

"Prefeasibility Study and Preliminary feasibility study mean a comprehensive study of the viability of a mineral project that has advanced to a stage where the mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, has been established, and which, if an effective method of mineral processing has been determined, includes a financial analysis based on reasonable assumptions of technical, engineering, operating, economic factors and the assessment of other relevant factors which are sufficient for a Qualified Person, acting reasonably, to determine if all or part of the Mineral Resource may be classified as a Mineral Reserve (adapted from NI 43-101, Section 1.2 Definitions). A Prefeasibility Study is at a lower confidence level than a feasibility study."

This definition indicates that a Prefeasibility Study can be used to define a mineral reserve for financial reporting. In practice, the Prefeasibility Study may examine a number of options for the project before selecting the optimal project to present for evaluation. As noted, the confidence level for a Prefeasibility Study is lower than a Feasibility Study, and as consequence not suitable for moving the project into financing and development. Frequently, the Prefeasibility Study will identify a substantial number of requirements for additional work such as drilling, metallurgical testwork, bulk sampling, pilot plant testwork, environmental testwork, etc. to allow the project to be evaluated a the full Feasibility Study level.

1.4 Feasibility Study

The feasibility study phase is started when the project developers consider that they have sufficient resources with adequate tons and grade and a suitable process selected to support the development of the project. Not infrequently, companies will enter into a feasibility process without having gone through adequate project definition and trade off studies that should have been done at the Scoping Study or Prefeasibility phase. From the point of view of cost estimation and project evaluation it is useful to describe the four main types of estimates usually prepared, and their purposes.

- Scoping – for project evaluations, definition, and trade off studies
- Prefeasibility – for final selection of project configuration
- Feasibility – for demonstration of project economic viability
- Definitive – for control of a project that has been approved and financed.

Appendix 2 provides a comparison of the four typical study types usually discussed in relation to feasibility studies and project evaluation. This table provides a checklist for evaluating the information requirements for the various estimate types and their position within the structure of the feasibility study. It is organized according to a typical table of contents for feasibility studies. The following sections discuss some salient aspects of the typical Feasibility Study.

1.4.1 Geology and Resource

The development of the analysis of the geology and the geological resource deservedly receives careful attention in the feasibility and will follow the CIM Guidelines. This includes relatively clear direction on the key issues:

- QA/QC
- Methods and data collection
- Sampling
- Drilling
- Sample security
- Preparation and assaying.

N.I. 43-101 and the companion CIM documents allow very limited use of Inferred resources in the economic analysis of the project provided that the Inferred are a small proportion of the ore body and that they are mined late in the life of the mine. The distinction between Inferred and Indicated is arbitrary based on decision rule chosen by modeler in their analysis of the deposit. The decision rules are written in the modeling software and might for example be as follows:

- Grade X thickness of greater than 0.4 tons Cu, or 2 oz Au
- Drill samples within 170 feet of the point
- Influence from 2 or more drill holes.

Criteria such as this create an on/off definition of Inferred and Indicated that doesn't consider the continuum of probability that exists in a mineral deposit. This essentially means that the geologist modeler must make an assessment on the risk and economics of the project without direct reference to all of the work that was performed to define the mining method; mining costs, processing costs, recoveries, and other factors that have a very significant influence on costs and project economics.

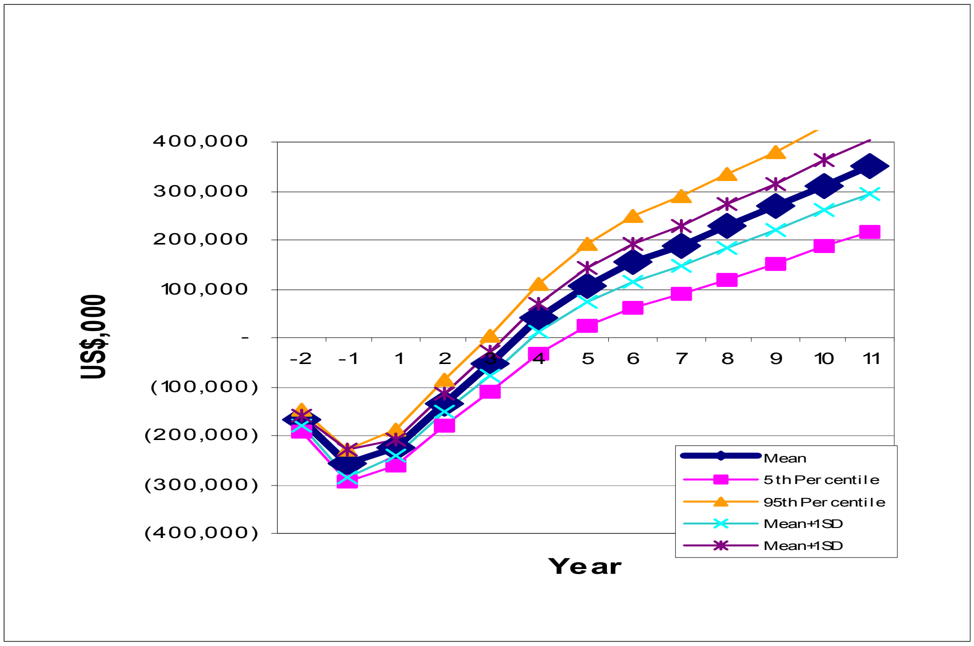
There are likely to be two results of this "exclusion" of Inferred resources from the evaluation of projects. Firstly, the development of underground mines will be more difficult due to high cost of additional drilling. Secondly, there will be pressure by the developers on the geologist, modeler, and geostatistician to stretch the boundary of Indicated in their evaluation criteria.

In order to overcome this difficulty, the industry could adopt method that would look at overall risk of project cash flow and set payback on that basis. Geostatisticians will normally set out a probability criteria, for example an 85% single-sided confidence interval for Indicated resources. This provides the analytical basis for the above analysis, but does not address the on/off break between Indicated and Inferred.

This could be accomplished by such techniques as using a conditional simulation to develop statistics for the grade, thickness, and other key determinants of mill feed tons and grade and mine operating costs. Such data can be used together with the financial model data to carry out a Monte Carlo simulation of the project financial including variability for capital and operating costs. This would allow development of confidence intervals for the financial performance of the project and evaluation of projects based on more objective criteria, i.e., a project having an 85% probability of paying back the loan (or investment) in 50% of the mine life would be considered as acceptable.

The following Figure 2 shows the type of analysis that can be accomplished using this approach. This would allow the assessment of project economics and loan repayment on a more objective basis, examining the entire mineral deposit and setting the probability criteria in full knowledge of the project configuration, scope, costs, and economics.

Figure 2: Probability Envelope for Cumulative Cash Flow from Project



1.4.2 Mine Design and Mineable Reserve

For an underground mine it is essential to develop a mine plan and model which considers all aspects of the mine design and operation; i.e., access, ramp vs. shaft, conveyance - conveyor vs. hoist, mining methods, ore access, backfill requirements, ore haulage, ventilation, etc.

Open pit mines obviously present a different set of issues; pit optimization (floating cones) are critical and we sometimes see that pits are generated without reference to mining and such niceties as ramps.

Tradeoff studies and optimization studies need to be conducted in a systematic fashion and careful attention paid to optimization of the whole operation. Often mining engineers and geologists (indeed any engineer or other expert) can become trapped in their own paradigms and sub-optimze the system with often serious impacts on operations, performance, and project economics.

The mine design provides a huge opportunity and risk for the capital costs, operating costs, mineral recovery, and project economics.

1.4.3 Metallurgy and Process Facility

The process selection and design is critical to the success of the project. Projects have run into serious problems including economic failure due to oversights in ore characterization and testwork. Sampling must be carefully carried out to ensure that samples used in the metallurgical testwork are indeed representative of the whole ore body. Many critical ore characteristics can vary substantially throughout the mineral deposit. Critical parameters that must be fully defined include:

- Grinding work indices
- SAG milling characteristics (i.e., critical size build-up and need for pebble crushing)
- Feed size and liberation for leaching, flotation and gravity
- Settling characteristics
- Filtration characteristics.

Bulk sampling and pilot scale testwork is the obvious, but expensive solution and if the bulk sample is not truly representative can be quite problematic.

The track record for new technology has been poor in recent years. Proven technology is always preferred. If new technology is used then pilot plant and depending on the technology, a commercial demonstration plant is essential.

1.4.4 Other Key Sections of the Feasibility Study

These key areas which must be fully defined include the following:

- Tailing disposal
- Infrastructure, power supply, water supply
- Civil and major earthworks
- Power supply
- Water
- Support facilities, maintenance, etc.

- Site access, road vs. fly-in fly-out vs. winter road vs. marine etc.
- Supply costs and shipping of product and impact on working capital
- Project access and transportation
- Environmental impacts and mitigation
- Labour supply and socio-economic issues
- Political stability and conditions
- Environmental constraints and permitting
- Management capability and experience
- Socio-economic impacts
- Project schedule and execution plan
- Capital and operating cost estimates.

The feasibility process includes a tension between the Owner's desire to have a viable project with low capital and operating costs, and the Engineer's desire to design conservatively to maximize the likelihood of a technically successful project. There are many aspects of a project, and all require careful attention. Some key aspects include the following.

Civil works are often highest risk and least appreciated, possibly because the engineers tend to focus on mining and process. Major earthworks carry a high risk due to geotechnical uncertainty. Field investigations and intelligent design and mitigation plans can reduce this risk, but civil overruns of 30% to 100% are not uncommon as can be seen from recent problems with Inco's Goro project.

Process design and flowsheets must consider the adequacy of surge capacity, standby equipment, bypasses, materials of construction and many other factors that relate to operability of the plant and its operating costs. Adequate estimation of labour and maintenance costs is critical to successful projects.

The estimation of capital costs must be based on realistic labour costs, and the scope must include a complete operable project with sufficient allowance for recruiting, training, commissioning, startup and the inevitable modifications required to ramp up to full commercial production. Appendix 2 presents a comprehensive checklist for studies and shows the requirements for various levels of cost estimates.

The estimation of capital cost is always a challenging activity and requires detailed planning, adequate design, reasonable quantity estimates, and good supporting cost information. Appendix 2 provides a checklist of the information requirements for a typical feasibility estimate and the levels of accuracy that might be expected. It should be noted that costs are almost always skewed to the upside, i.e., it is more likely that the schedule will stretch out, problems will occur, prices will rise, and consequently costs will increase.

The problem of assessment of the capital cost contingency is a critical problem in project evaluation and budgeting. The method of determining the level of allocation for extra costs within the scope of the project should be carried out using a Monte Carlo simulation technique. Contingency is then selected to provide an 80% or some other level of confidence that the project will be completed within the budgeted capital cost.

Figure 3 shows the predicted capital cost for a mining type project based on a capital cost risk analysis. This figure shows two curves, one for the project as defined by the Feasibility Engineering company, and the second for the project with the Owner's risk included in the analysis. The first may be the project budget, but the second is the capital cost that the Bank will want to find coverage for.

Figure 4 shows the histogram for project capital cost based on the same Monte Carlo risk analysis. It should be noted that this cost distribution is skewed to the high side, and with a relatively long tail.

Figure 3: Typical Capital Cost Probability S Curves

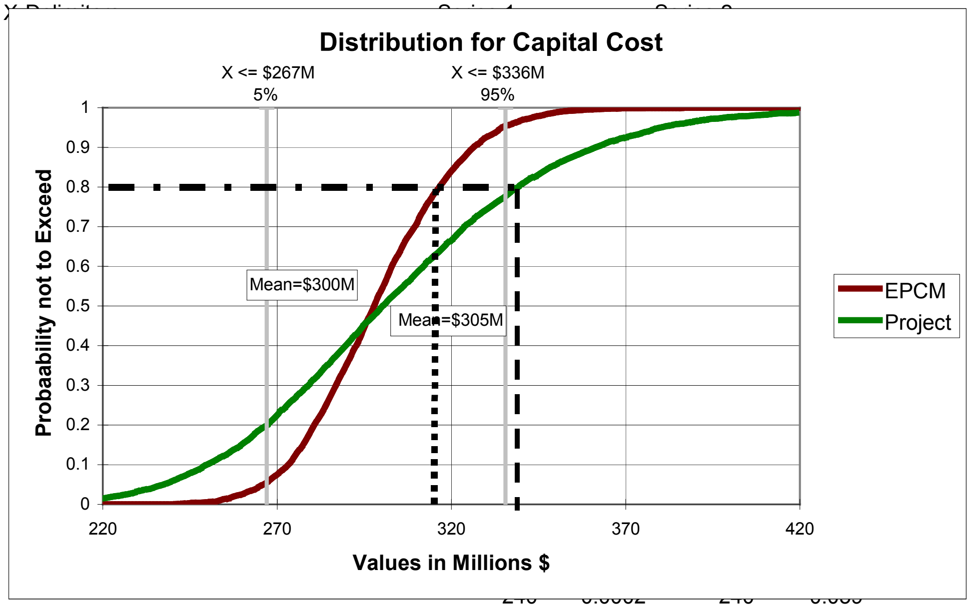
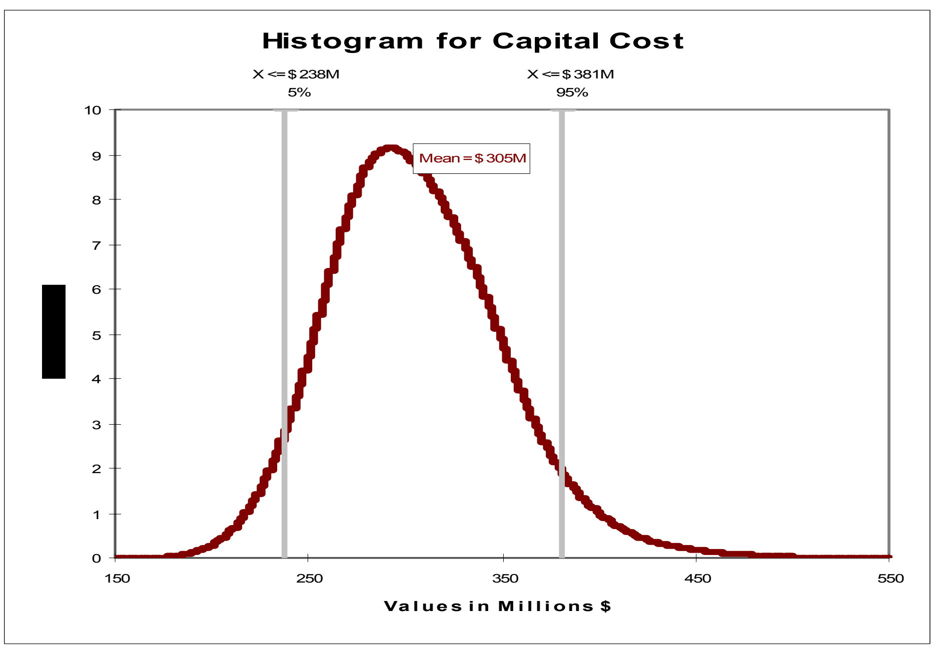


Figure 4: Typical Capital Cost Probability Distribution



Skewed

The schedule and construction plan can be overly optimistic, especially in remote locations where activity is controlled by logistical requirements. This area requires substantial investigation into local labour and contracting practices and can be greatly aided by discussions and assistance from contractors experienced in the area and type of work. It should be pointed out that such support must be carefully evaluated and used with caution as contractors can be rather self serving especially with respect to cost information as they have the obvious desire to bid the work at a price below the "budget".

The financial analysis is the penultimate stage of the project evaluation and feasibility, where the project cash flows are modeled and the NPV and IRR of the project are determined. The model is complex and is always most sensitive to metal prices. Next in terms of sensitivity, capital and operating costs. The feasibility financial model should consider all aspects of the cash flow, i.e., financing costs, interest during construction, royalties, taxes, sustaining capital, reclamation and closure, etc.

The final consideration in a feasibility study should include risk assessment and mitigation.

The major risks inherent in the project include:

- Reserve and mining risk
- Process risk
- Political risk
- Environmental risk
- Exchange and interest rate risk
- Transportation and logistics risk
- Force majeure risk
- Commodity price risk.

Mining and reserve risk are related to factors such as the confidence in the grade and thickness estimations that have gone into the geological model. As discussed earlier the determination of measured, indicated and inferred resources is a function of the geologist and (hopefully) geostatisticians' opinions regarding what is an acceptable degree of confidence. This gets translated into a mining plan complete with a mining method, costs, recovery and dilution. Each step has uncertainty and risk with variability in such factors as vein thickness and grade potentially having a compounding effect on costs and productivity. This is on aspect of risk that is typically not treated in an analytic fashion, but rather, subjectively and based on sensitivity type analysis.

These remaining risks, depending on the project, can all have equally dramatic impact on project performance and economics and should be carefully reviewed, described and analyzed. Process risk has been discussed earlier and could easily be the subject of a separate paper.

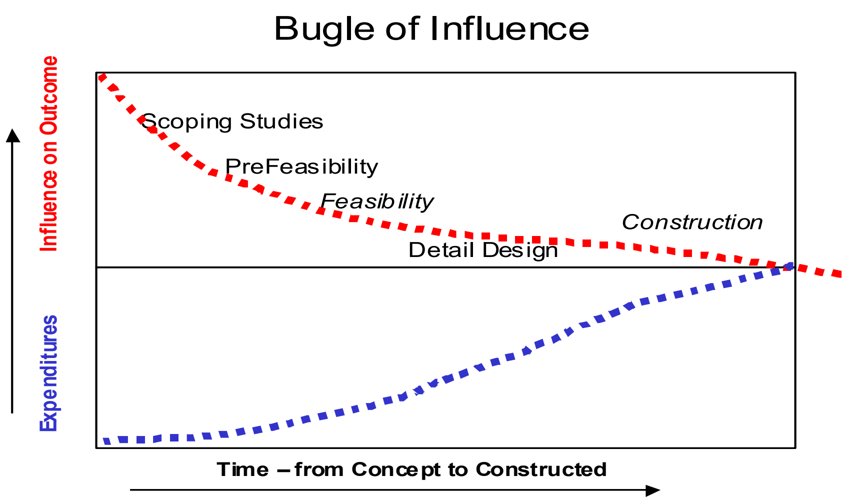
Political, socioeconomic, and environmental risks are related to the external environment of the project and can likewise have a profound impact on the outcome of the project. Bougainville remains a milestone in mining history resulting from political and socioeconomic uncertainty. Prudence would dictate that considerable effort should be expended on analyzing these risk areas especially in third world projects.

Transportation and logistics risk is a related issue that is frequently a source of problems in remote projects. Costs and schedules can spiral out of control if transportation systems do not function well.

Force majeure risks such as weather disruptions, earthquake, fire, are normally covered by project insurance, however the deductibles can be quite high and the residual risk substantial.

The cost impact and overall economic impact the above risks should be examined by applying a risk analysis methodology to the overall project financial model. Mitigation measures should then be developed and applied to control risk.

Figure 5: Ability to Influence Project Outcome and Expenditure Levels



1.5 Project Approval and Financing

After the feasibility study, provided the project has sufficient merit, the project is financed and moves into the project implementation phase, moving through the following stages:

- Design
- Procurement
- Construction
- Commissioning and startup
- Commercial production for life-of-mine
- Reclamation and closure.

1.5.1 The Key Players, their Roles and Motivations

In order to understand the feasibility process and the financing of mining projects, we must look at the key players, their motivations and their risks profiles. Typically for a mining project these key players would include: the junior mining company, a major mining company, an engineering company, bankers or financiers, and finally the banker's independent reviewer. Each of these parties has different goals and motivations and each is likely to act in its own self-interest within the constraints of their agreements and professional requirements.

Junior - proponent and most likely to profit from project, typically focused on presenting the project in the best possible light. The Junior is often faced with the classic dilemma; they cannot finance the project due to low market capitalization and inability to raise sufficient new equity without unacceptable dilution. Depending on the phase of development the choices include:

- Sell the project or a large portion, and probably lose control
- Make an agreement with a Major, who earns into the project by carrying the project to feasibility, and makes certain commitments to finance the project
- If the project is more advanced, possibly obtain support from product off-takers, or structure so that EPC contractor carries sufficient risk to allow financing.

Juniors and other exploration groups will usually enter into an agreement with a major mining company as the project becomes more advanced and the capital requirements increase. These agreements will often include provisions that address:

- Development responsibility, funding participation and ownership at various phases especially after preparation of a "bankable" feasibility study
- Operatorship for the project
- Royalties
- Financing of the project following.

The Junior wants to finance the project with " Non-Recourse" project financing. For all but the very best of projects this is probably an illusion. The best scenario in recent years, for financing would be to obtain a "Limited Recourse" loan for the project. Limited Recourse Loans rely on the project, but must be backstopped, typically by the balance sheet of the Major. This fundamental issue is probably the key determinant in the negotiating dynamic between the

Junior and the Major. Risk allocation and risk assumption is a key issue in project financing. The Junior is typically resource constrained and must seek other options, usually an earn in agreement with a major to carry the project forward and ultimately arrive with a project with a positive feasibility study that will support financing.

The Major Mining Company - an investor acquiring an asset. The Major will tend to be conservative, skeptical, and is usually paying the bills during an earn-in type of feasibility arrangement. The Major is interested in the project because they believe that it has the potential to make a mine. The Major is investing the hard-earned money gleaned from operations and investors who expect steady long term growth and earnings not speculative profits. The Major has a well-developed management structure in place, an operating culture and a project development philosophy, and therefore want control and will often demand a management contract.

Major Engineering Companies – hired by the Major to do the feasibility study. The Engineer should be highly professional in approach and creative in defining the project. A multi-disciplinary team carries out the study and examines all aspects of the project. The feasibility can be split up amongst a number of specialist groups if all the requisite skills are not available in one company. This approach can be problematic, as coordination can suffer and sub-optimization can occur due to the lack of a team approach.

The QP and the Engineering companies in their roles as technical experts and preparers, or reviewers of feasibility studies, acquire significant exposure to potential liability for such work and their recommendations.

Bankers - being asked to provide debt finance for the project. Banks will view the project as a cash flow and will use low commodity prices to evaluate the performance of the project. The banks primary concern will be loan coverage from cash flow, NPV and IRR are irrelevant. The banks will subject the project to a usually rigorous third party review and there are likely to be many issues. The notion of a "bankable" feasibility study is somewhat dubious as it is only through this review process and the banks own analysis of the ability of the project to support the required level of debt that a decision to finance will be made. The following comment from a banker is instructive:

"A bankable document is one that satisfactorily provides all of the information and auditing necessary for the bank and its engineer to determine that the risks are acceptable and the project is viable, on a standalone project finance basis ...less than 10% provide completely satisfactory information ...."

Independent Reviewers – hired by the Bankers to review the project, the feasibility study, and to critically examine all aspects of the project and uncover serious or fatal flaws. The external reviewers primary function is to protect the bank from lending to poor projects. An important motivation is to earn fees and maintain his own reputation, so such reviews will necessarily be very conservative.

For the Developer, the Major, and the Banker there are some difficult decisions: the project configuration, the Engineer, and the Reviewer. Current wisdom suggests that ***" You must choose, but choose wisely"***

The key is intelligent selection of the project configuration. There is no simple answer, only by getting the best support, advice, and engineering available, and spending the time and money to get second opinions and evaluate options, will it be possible to optimize the project. This will provide the best economics and the fastest time to develop the project.

1.6 The Feasibility Study and the Project Agreement

The current usage of Rocky Mountain Form 5 type agreements today, have a major earning into the project by carrying out certain obligation, e.g., expending exploration money, drilling, and funding the feasibility study. The feasibility study then triggers obligations to develop the property, invest or fund or finance the implementation phase. The intention is for the major to fund the feasibility and carry the junior to a production decision. As a result of such activity the Major's interest in the project often becomes vested on delivery of the feasibility study.

Implicit in this approach is the concept of "non-recourse" project finance and "bankability" where a junior hopes to be able to finance their portion of the project using bank debt, thereby avoiding the diluting effect of raising additional equity.

Typically the major or investing/acquiring party will vest its interest on funding and completion of a feasibility study. In an effort to avoid the difficulties of a feasibility study which shows poor or marginal economics, juniors may insist on the major delivering a "positive feasibility study". Such an approach has little value because one can always find a metal price that yields good economics.

The conflict of objectives arises because the Junior needs the Major to carry it through feasibility, but is worried the Major may decide the project is acceptable to keep and hold, but not a project for immediate development. Such an outcome can destroy the value of the Junior. The current earn-in model used by Juniors and Majors can and does create many problems and conflicts and should probably be re-examined.

Alternative models have been suggested such as; adopting a more participative relation, success fees for the junior, a private placement structure to provide the junior with financial support for continuing its exploration efforts, or increasing the Major's share through cash infusions rather than vesting.

1.7 Conclusion - Feasibility Study

The principle purpose of a feasibility study is to demonstrate the technical and economic viability of the proposed project to expert third parties for the purpose of obtaining financing for the project.

Define the risks and propose a coherent and effective plan for mitigation. The level of risk assumed by the parties to a project is related to quality of the feasibility study, the quality of the concepts, the depth of analysis, and the team of people doing the work.

Scoping the right project will improve economics and performance more than any other aspect. The concepts should be rigorously evaluated as early as possible and a major effort expended on trade off studies to optimize the project prior to carrying out the final feasibility study. Define the project completely and be sure it will work as planned.

Remember that risks are skewed, costs are always more likely to go up than down. Structured risk analysis provides a valuable tool for evaluating, planning and controlling projects. Define the risks and identify appropriate mitigation measures.

Do the tradeoff and optimization studies early because the effort expended on testwork, engineering, and planning has a much greater impact when done intelligently in the early phases of the project.

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10.4 Political Environment
10.5 Legal, and Regulatory Framework

11.0 **PROJECT PLAN AND CONSTRUCTION SCHEDULE**
11.1 Summary and Conclusions
11.2 Project Execution Plan
11.3 Project Construction Planning
11.4 Project Schedule

12.0 **CAPITAL COSTS**
12.1 Summary and Conclusions
12.2 Basis of Estimate
12.3 Direct Cost Estimate
12.4 Construction Indirect Cost Estimate
12.5 Contingency and Risk Analysis
12.6 Sustaining Capital
12.7 Reclamation and Closure

13.0 **OPERATING COSTS**
13.1 Summary and Conclusions
13.2 Estimate Basis
13.3 Mine Operating Costs
13.4 Process Plant Operating Costs
13.5 General and Administration

14.0 **FINANCIAL EVALUATION**
14.1 Summary and Conclusions
14.2 Valuation Methodology
14.3 Marketing of Product
14.4 Assumptions
14.5 Results and Sensitivity Analysis

APPENDIX 2 Study Type & Characteristics

Item	Scoping Study	Prefeasibility Study	Feasibility Study	Definitive Estimate
Project				
1.1 Annual Production	Selected - Tradeoffs & Judgement	Optimized - Tradeoffs	Fixed	Fixed
1.2 Terms of Reference & Purpose	Study for directing development. Options are studied & economic tradeoffs made	Study to examine options and optimize project. Basis for major expenditures, such as test mining. Options are studied in sufficient detail to select the optimal project configuration.	Study to fully define project scope, costs, schedule & economics. Purpose is to support and investment decision and financing.	Project Control Estimate for project financed & being designed. Purpose is to provide a current control estimate for the final cost of the project.
1.3 Project Location Data	Minimal	Defined	Detailed	
Engineering Effort	low	2%	5-10%	30-50%
Engineering Cost				
2.0 **LAND TENURE**				
2.1 Project History	Preliminary		Studied	
2.2 Land Position and Claims		Defined	Legal Opinion	
2.3 Property Tenure		Defined	Legal Opinion	
3.0 **GEOLOGY**				
3.1 Purpose	Exploration & definition	Resource definition	Define Mineral Resource	
3.2 Geological Setting	Known	Studied	Final	
3.3 Data Compilation and Analysis	Some	Preliminary	Definitive	
3.4 Spatial (Variographic) Analysis	Some	Preliminary	Definitive	
3.5 Geological Model	Conceptual	Preliminary	Definitive	
3.6 Geological Resource	Conceptual	Preliminary	Definitive	
4.0 **MINING AND ORE RESERVES**				
Underground Mine				
4.2 Mineable Reserve	Conceptual	Preliminary	Yes – Based on Study Economics	
4.3 Mine Design		Preliminary	Final	
4.4 Mining Method		Preliminary	Defined	
4.5 Ore Body Access & Conveyance	Conceptual	Preliminary	Final	Designed
4.6 Mine Development, Ore and Waste Circuits		Preliminary	Final	
4.8 Mine Ventilation		Preliminary	Yes	
4.9 Mine Services		Preliminary	Defined & Estimated	
4.10 Ground Conditions and Hydrogeology Mine Services		Preliminary	Definitive	
Operating Costs	Comparative	Preliminary	Detailed Estimates	
Open Pit Mine				
4.2 Mineable Reserve	Conceptual	Preliminary	Yes – Based on Study Economics	
4.3 Pit Optimization & Design	Conceptual Pit, but with ramp and other mining considerations	Preliminary pit optimization including ramp access	Final optimized pit	

Item	Scoping Study	Prefeasibility Study	Feasibility Study	Definitive Estimate
4.4 Bench Height & Equipment Selection		Preliminary	Final, bench & equipment matched, waste dumps designed	
4.5 Ramp System		Preliminary	Final	
Geotechnical & Pit Slopes		Preliminary	Definitive	
Operating Costs	Comparative	Preliminary	Detailed Estimate based on selected equipment & productivity	
5.0 **METALLURGY AND PROCESS FACILITY**				
5.1 Process Flowsheet	Conceptual	Preliminary	Optimized	Final
Metallurgical Sampling	Grab & Drilled	Drilled - representative	Drilled and bulk - representative	
5.2 Metallurgical Testwork	Some Bench	Bench Scale	Pilot Plant	
5.3 Design Criteria	No	Major items	Detailed	Final
5.4 Process Control	No	Conceptual	Defined	Final
Mass & Energy Balances	No	Preliminary	Final	
5.4 Equipment Selection	Conceptual	Preliminary – Historical pricing & some quotes	Optimized- Vendor Quotes	Purchased
5.5 General Arrangements	No	Minimal	Preliminary	Detailed
P&IDs	No	No	Sometimes	Detailed
Piping Layouts	No	No	Not usual	
Electrical Single Lines	No	Preliminary	Well defined	Detailed
Equipment Specifications	No	No	Major items only	Yes all
Process Buildings	No	Preliminary GA	Layout & quote	Purchased
6.0 **INFRASTRUCTURE and SURFACE FACILITIES**				
6.1 Scope	Conceptual	Preliminary	Well Defined	Definitive & Detailed
6.2 Site Geotechnical Considerations	Not considered	Preliminary investigations	Definitive and detailed site investigations	Actual excavations and foundations established
6.3 Camp, Offices & Ancillaries		Preliminary	Definitive	Definitive & Detailed
6.4 Mine Maintenance Shop		Preliminary	Definitive	Definitive & Detailed
6.5 Site Power Distribution		Preliminary	Definitive	Definitive & Detailed
6.6 Power Supply – Powerline or Generation	Sometimes	Defined – Tradeoffs done & system selected	Definitive – costs confirmed	Definitive & Detailed
6.7 Water Supply - Fresh, Potable, & Fire Systems	Sometimes	Field investigations Defined	Definitive	Definitive & Detailed
6.6 Sewage and Waste Disposal		Preliminary	Defined	Definitive & Detailed
6.8 Security		Preliminary	Defined	Contracted
6.9 Site Drainage		Preliminary	Conceptual	Definitive & Detailed
6.10 Water Treatment System		Preliminary	Definitive –design	Definitive & Detailed
6.11 Site Roads		Preliminary	Definitive – Drawings	Definitive & Detailed
6.12 Communications		Preliminary	System selected	Definitive & Detailed
6.13 Fuel Storage		Preliminary	Defined	Definitive & Detailed
7.0 **TRANSPORTATION**				
7.1 Site Access	Conceptual	Preliminary	Well Defined	Under construction
7.2 Transport System	No	Yes	Final	Contracts awarded
7.3 Site Access Road	No	Conceptual	Final	
7.4 Ocean Transport & Ports	No	Conceptual	Final	Contracts awarded
7.5 Air Transport	No	Conceptual	Final	Contracts awarded
8.0 **TAILINGS DISPOSAL**				
8.1 Selection of Disposal Method	Conceptual	Tradeoffs & selection of method	Final design submitted for permitting	Pemitted
8.2 System Design & Description		Preliminary	Final	Permitted

Item		Scoping Study	Prefeasibility Study	Feasibility Study	Definitive Estimate
8.3	Geotechnical Design		Field investigation & study	Definitive investigations	Permitted
9.0	**ENVIRONMENTAL CONSIDERATIONS**				
9.2	Physical, Ecological, Setting	Not investigated	Preliminary investigations	Defined and assessed	
9.3	Policy, Legal, and Regulatory Framework	Not investigated	Preliminary investigations	Defined & permitting in progress	Permits issued
9.4	Existing Baseline Data and Requirements	No	Baseline Studies underway	Final Baseline	Permits issued
9.5	Potential Impacts		Conceptual, all major impacts identified and risks assessed	Defined – permitting in progress, impacts completely characterized	Permits issued
	Geochemical and ARD	Not considered	ARD testwork in progress	Complete ARD testwork program, characterized, & mitigation defined	Permits issued
	Water Discharge Modeling of quantity and quality	No	Preliminary investigations for permitting	Definitive modeling in support of permit applications	Permits issued
9.6	Mitigation and Management Plans		Conceptual	Concepts defined, plan described & costed	Environmental systems in place
9.7	Reclamation and Closure		Conceptual	Concepts defined, costs estimated	Permits issued, mitigation measures in place
9.7	Permitting Status, Schedule, and Process		Initial discussions with permitting agencies	Permitting is advanced to allow some credible prediction of schedule	Permits issued
10.0	**SOCIOECONOMIC AND POLITICAL CONSIDERATIONS**				
10.2	Political and Sociological Environment	Subjective	Required to assess risk	Essential to project risk assessment	Agreements & permits in place
10.3	Labour Supply and Conditions	Not assessed	Should be assessed	Basis for Capital and operating cost estimates.	Some of workforce hired, costs fully defined
10.4	Legal, and Regulatory Framework	Subjective	Legal review should be done		
11	**PROJECT PLAN AND CONSTRUCTION SCHEDULE**				
11.1	Project Execution Plan	No	Preliminary	Defined	Implemented
11.2	Contracting Plan	No	Conceptual	Contract Packages & type identified	Implemented
11.3	Project Construction Planning	No	Conceptual		Implemented
11.4	Project Schedule	Conceptual	Yes 100- 500 activities	Well defined, EPC schedule 300-1000 activities	Detailed execution schedule in progress
12	**CAPITAL COSTS**				
12.1	Accuracy Target	**-25%+30%**	**-15%+20%**	**-10%+15%**	**-5%+10%**
12.2	Basis of Estimate	Conceptual,	Preliminary designs	Defined project,	Detail design, all major design decisions are made.
12.3	Direct Cost Estimate	Similar projects,	Drawings & design, see above	Drawings & design, see above	Detailed Estimate
	Process units	- capacity factors	- equipment list	- equipment quotes	- quotes & awards
	Equipment	- historical prices	- factored & sketches	- sketches & MTOs	- Vendor awarded prices
	Civil Structural Works	factored	labour estimated	Labour estimated	MTOs $/ton quotes
	Installation	factored	Estimated & factored	Labour estimated	actuals & estimates

	Item	Scoping Study	Prefeasibility Study	Feasibility Study	Definitive Estimate
	Electrical & Instrumentation	factored	factored, % or $/hp	Estimated & factored	MTOs
	Labour rates	implicit	Published & surveyed	Surveyed & contractors	Actuals
12.4	Construction Indirect Cost Estimate	Factored	Factored & estimate project specific	Estimated in detail based on above especially 11, EPCM estimate	Detailed
12.5	Capex Risk Analysis	Possibly Conceptual	Preliminary risk analysis	All cost risks assessed in formal process	All cost risks assessed in formal process
	-				
12.6	Contingency Range	20% -30%	10% -20%	8% - 15%	5% - 10%
12.7	Sustaining Capital	No	Conceptual	Defined and estimated	Detailed
13.0	**OPERATING COSTS**				N/A
13.2	Estimate Basis	Historical projects	Estimate	Detailed estimate	Final quotes & contracts
	Labour rates & burdens	published	investigate	investigate & contracts	Staffing underway
	Fuel Costs	published	budget quote	Quote	Supply contract
	Power Costs	published	budget quote	Quote	Supply contract
	Reagents	published	data & quotes	Quotations	Definitive prices
	Consumables	published	factor	estimate & quotes	Definitive prices
13.3	Mine Operating Costs	Similar projects	Estimated	Detail estimate as part of mine cost model	Definitive prices & contracts
13.4	Process Plant Operating Costs	Similar projects	Estimated	Detail process operating cost estimate	Definitive prices & contracts
13.5	General and Administration	Similar projects	Factored or estimated	Detailed, including local taxes, insurance, admin, catering, site & infrastructure costs	
14.0	**FINANCIAL EVALUATION**				
14.2	Valuation Methodology	Simple DCF model	DCF Model	DCF Model	DCF Model, corporate income & balance sheet
	Taxes	Conceptual	Preliminary	Definitive, Legal	Definitive, Legal
	Royalties	Assumed	Defined	Final & binding	Signed contracts
14.3	Marketing of Product	Assumed	Preliminary enquiries	Marketing study with frame contracts	Signed contracts
14.4	Results and Sensitivity Analysis	Conceptual NPV & IRR	Full sensitivity analysis	Full sensitivity analysis	
15.0	**RISKS AND MITIGATION**				
15.2	Risk Allocation		Preliminary assessment	Contracting & financing plan	Implemented
15.3	Geological and Mining Risks		Preliminary assessment	Thoroughly assessed	
15.4	Processing Risk		Preliminary assessment	Thoroughly assessed	
15.5	Execution and Completion Risk			Thoroughly assessed	
15.6	Political Risk	Considered	Preliminary assessment	Thoroughly assessed	
15.7	Economic and Market Risk	Considered	Preliminary assessment	Thoroughly assessed	
15.8	Project Risk Analysis	No	Establish project risk model	Complete formal project risk assessment and model	