HOME

Effective Mining Project Management Systems

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ABSTRACT

Reports of delays and cost blowouts in major study and construction projects are becoming increasingly prevalent in the resources industry. This is mainly being attributed to an escalating cost environment associated with the increased number of projects in the development to construction pipeline and a scarcity of competent skilled resources to deliver these projects.

However, not all this effect can be directly attributed to the current environment. Historically the mining industry has not performed well in its ability to deliver projects according to the financial and physical parameters forecast in the feasibility study process.

To manage the risks associated with delivery of major projects, resource companies need to ensure they use a standardised approach to management of their project development to satisfy project objectives and enable more efficient use of the increasingly limited available resources. Each discrete step in advancing the project from scoping study to operations needs to be integrated, reducing the amount of rework and duplication.

This paper is primarily a consolidation of existing ideas on project management systems but also introduces new concepts to solve current issues. It describes the basic components of a typical mining project, the issues that commonly arise, the key attributes, and critical steps required for an effective integrated project management system covering projects from initial scoping studies through to project commissioning and operation. This paper focuses on technical study components of the mine development project with allowance for transitioning to design and construction and operation phases.

INTRODUCTION

The pace and scale of current developments in Australia's mineral resources sector is unprecedented.

In the past 18 months, 62 major minerals and energy development projects, valued at around $16.2 billion, were brought into production. The Australian Bureau of Agricultural and Resource Economics (ABARE, 2006) April 2006 list of major minerals and energy projects lists a record 90 projects, valued at around $34 billion, that are committed or under construction, with a further 166 projects under consideration for development.

Based on ABS survey data, in real (2005-06 dollar) terms, new capital expenditure in the mining industry in 2005-06 was the highest on record, 79 per cent higher than the average annual expenditure for the past 25 years ($7.9 billion). Based on industry intentions canvassed in the March quarter 2006, ABS data indicate that capital expenditure on mining in 2006-07 may increase to around $15.7 billion (ABARE, 2006).

In this environment, where demand from the construction sector for labour, equipment and materials is rising faster than supply, the impact on project development is being manifested in delays to scheduled completion dates and increases in project capital costs. Of 22 advanced minerals and energy projects in ABARE's April 2006 project list that were also in the October 2005 list, 16 (or over 70 per cent) now show a later scheduled completion date compared with six months ago. In terms of capital costs, of 30 projects in the October list that were either completed in the six months ended April or still appear in the April 2006 list, 18 (or 60 per cent) show capital cost increases. Some of these increases are substantial (ABARE, 2006).

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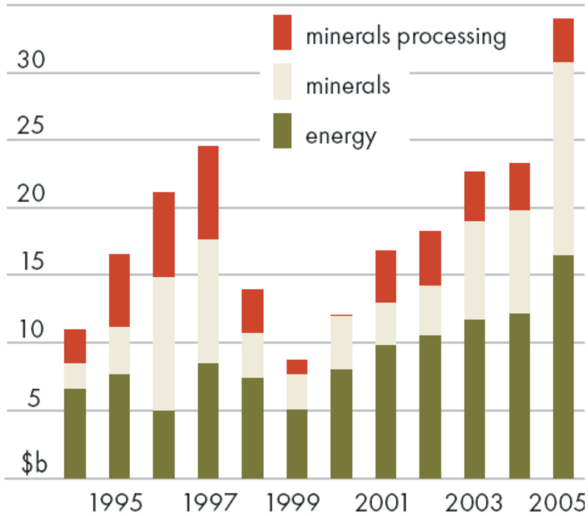


FIG 1 - Value of advanced resource and energy development projects in 2005-06 dollars (ABARE, 2006).

Table 1 describes a list of recent high profile mining projects reporting cost overruns in the media.

TABLE 1

List of recent major mining project cost overruns.

Project	Company	Feasibility budget cost	Actual/ forecast cost overrun
Ravensthorpe/ Yabilu Expansion	BHP Billiton	A$1.4 billion	30%
Spence (Chile)	BHP Billiton	US$990 million	10%
Telfer Mine	Newcrest	A$1.19 billion	17.5%
Stanwell Magnesium	AMC	A$1.3 billion	30%
Boddington	Newmont	A$866 million	100%
Goro Project (Indonesia)	Inco	US$1.45 billion	15%
Prominent Hill Project	Oxiana	A$350 million	51%

Whilst the current operating environment is a contributing factor, upon closer examination these symptoms are not entirely a new phenomenon that can be attributed to only the recent escalating cost environment and shortage of resources.

A study of 18 mining projects covering the period 1965 to 1981 showed an average cost overrun of 33 per cent compared to feasibility study estimates (Castle, 1985). A study of 60 mining projects covering the period from 1980 to 2001 showed average cost overruns of 22 per cent with almost half of the projects reporting overruns of more than 20 per cent (Gypton, 2002). A review of 16 mining projects carried out in the 1990s showed an average cost overrun of 25 per cent, attributed to overly optimistic feasibility studies and poor cost estimation (Anon, 2000).

In fact, there is evidence to suggest that even before the recent commodities boom, the performance of feasibility studies is no better than it was in the 1970s despite the advent of spreadsheets and sophisticated financial modelling software (McCarthy, 2003).

Mining is at best an inexact science. Technical projects involve complex interrelationships between departmental 'silos' within an organisation as well as with external consultants and stakeholders. They do and will always rely very heavily on the experience of the people involved. Any shortage of available skilled resource will only tend to exacerbate inadequacies in systems governing these processes.

What is required is a standardised approach to management of the processes controlling projects that also addresses common issues currently being realised within projects today. This will ensure projects are managed efficiently and maximise the opportunity to achieve standardised and predictable outcomes within an environment of constrained resources.

COMMON PROCEDURAL ISSUES

All projects are required to address a multitude of technical issues and risks, each of which individually or collectively can contribute to the failure of projects. However, without considering the detail of all these technical risks, good project management procedures should govern a process that minimises technical risk.

Common issues relating to the project management procedures (which can manifest failure to recognise technical risks) are highlighted below:

Mineral resource/reserve

Mineral resource/reserve problems are the most likely technical problem to account for failure of mining projects (Shillabeer and Gypton, 2003). Mineral resources should be audited, defined and reported according to the relevant code of practise *before* each relevant phase of the project. Modifying the resource base because of geological reinterpretation or information obtained during the course of a study phase is often the cause of rework and delays. Whilst there are no hard and fast rules for prerequisite resource definitions for each phase, resources need to be understood in light of the coding procedure that has been followed.

Mining rates

Problems occur when the mining rate prediction model is not defined and agreed before commencement of the study project. There can be temptation to 'crank up' the mining rate to unrealistic levels in order to exceed the financial hurdle for the project. Several studies have tried to correlate the relationship between mining rate and ore reserve tonnage (Smith, 1997; McSpadden and Schaap, 1984) which can be used as a guide. McCarthy (2003) states if a challenging but achievable target is included in the feasibility study, the implied chance of failure probably exceeds 50 per cent.

Skipping steps

Skipping the prefeasibility or scoping study phase can lead to costly delays in the definitive feasibility study. Scoping studies are relatively short and inexpensive when compared to prefeasibility and definitive feasibility studies. If the scoping study proves that an option or the entire project is not viable, then significant expense in pursuing a non-viable option or project through the definitive feasibility stage can be avoided.

One common finding from scoping studies is that more metallurgical information, drilling or sampling is required to ensure that there is sufficient information to precise the shortlist of operating scenarios. As this information can be expensive and time consuming to obtain, the scoping study can quickly evaluate these needs. This is an important outcome to ensure realistic budgets and schedules are developed and communicated for the entire project.

Modelling

One of the major issues in the early phases of a mine development project is oversimplifying the level of complexity involved. Whilst the level of accuracy is not always high, each phase of the study process often involves a complex series of iterations. For each operating scenario, costs are derived and resources optimised to generate preliminary mine shells. The characteristics of the mine shell in turn generate ideas to reduce costs or risks. These new ideas are then costed and mineral resources re-optimised in each case.

In a dynamic environment, this cycle can continue indefinitely unless the project team maintains a diligent approach of analysing only to the level that the phase requires. The question needs to be asked as to whether by doing a reiteration it is likely to result in a particular option being otherwise excluded or included in the shortlist of options to advance to the next phase. If the answer is no, then further refinements of a viable option may not be efficient until later phases.

Unrealistic time frames

Technical studies required for bringing mining operations into production are expensive and time consuming. The entire mining project from scoping to completion of the definitive feasibility study, including inter-study work plans for a world-scale mining operation, may take up to ten years. If business needs suggest that shorter time frames than what is optimal are required, then the corresponding increase in risk profile needs to be understood and communicated.

Unrealistic time frames and budgets often result in projects being rushed to completion and failing to achieve their objectives. This may result in delaying recognition of major issues until after commitment to significant capital expenditure.

Leadership

Whilst short shrift is often given to commodity price models, it should be noted that most mine feasibility studies show that projects are most sensitive to 'uncontrollable' factors such as commodity price, tax and inflation than 'controllable' factors such as recoveries, capital and operating costs. In fact, it is normally possible to exceed any financial hurdle required without altering the technical details of the project, only altering the economic factors (Smith, 1997).

There is often pressure placed on project study teams to come up with a positive project outcome. Often projects undergo much iteration to come up with what is often a single estimate of project value. The result may hide the fact that projects are often biased towards parameters that produce a favourable project result.

Projects require strong leadership to counter this pressure and ensure the project team is focussed on presenting the project fairly rather than favourably. The project leader needs to be someone capable of presenting an unfavourable report when momentum within the business is high for a positive outcome.

Contingencies

Project cost estimates have historically shown a strong tendency to increase as the project advances. This is generally the result of poor knowledge and application of contingencies.

The 6 P's

Many projects fail due to lack of understanding the importance of the 6 P's rule (proper prior planning prevents poor performance).

THE PHASES OF AN EFFECTIVE MINING PROJECT

To understand what is required to control the risks in mining projects, the individual phases of these mining projects need to be understood and recommendations made as to what the focus and objectives of these phases should be.

The process of technical analysis to determine the viability of a mineral prospect is generally loosely categorised as a 'feasibility study'. In fact, a feasibility study is no single study in itself but a sequential series of interdependent technical studies with discrete objectives. Major projects generally have five distinct phases; scoping studies, prefeasibility studies, definitive feasibility studies, design and construction, and operations. Each project phase serves an important purpose and requires a specific set of management skills. Separate teams are generally used for the study, the design and construction, and operations phases in turn.

The initial phases of a project are broad in nature, looking at a range of options. As the project advances, the project phases become more detailed and focus on a single option.

Not all projects will progress through all phases. At the end of each phase, a decision is made whether to stop the project or progress to the next phase. If the decision to progress to the next phase is positive, a work plan is generally implemented. The work plan should be completed before commencement of the next phase to ensure that the necessary data is available to commence the next phase.

As the project advances through the phases, the level of definition and accuracy improves, however, generally, each study comprises as a minimum:

- go/no go recommendation;
- description of site;
- description of the project, work completed, findings and assumptions made;
- a mineral resource and ore reserve statement;
- strategic alignment analysis;
- market analysis;
- health, safety, environment and community (draft) plan;
- ownership, legal, financial and permit analysis and statement;
- shortlist and general design features of viable operating scenario/s and parameters of the project;
- estimates and sensitivity/statistical testing of capital and operating costs, revenue and profit;
- full spectrum risk analysis;
- work plan outline to be complete before commencement of the next phase; and
- estimated scope and budget for the next phase.

Project phases

Scoping study (Eliminate phase)

A scoping (concept) study should be used to define the potential of a project, *eliminate* those options that are unlikely to become optimal, and determine if there is sufficient opportunity to justify the investment required for further studies.

Typically, a number of operating scenarios are considered. It is critical that *all* potential operating scenarios be considered to prevent any unnecessary rework or delays in later study phases.

Before commencement of a scoping study there should be sufficient drilling and sampling completed to define a geological resource sufficient to be representative of the scale of the resource. Whilst the resource need not conform to any specific JORC (JORC, 2004) category, the resources should be stated according to JORC guidelines and be used as a 'sanity check' for data interpretation and reporting of risk. The resource models should be audited to understand what the data limitations and inherent risks are that may influence the mining and processing techniques being considered.

Due to the limitations of data and testwork generally available when entering into a scoping study, production schedules and cost estimates are normally simplistic and are generally derived based on experience, benchmarks and industry standards. First principles calculations are at times used based on broadly anticipated operating conditions. Engineering design specification to support processing costs is generally very limited.

Once the initial analysis of the options has been completed, a process of ranking is performed to develop a smaller subset of options for more detailed analysis in the prefeasibility study. Only those options that are deemed beyond reasonable doubt to be unlikely to become the most viable operating scenario should then be precluded from advancing to the next study phase. Optimistic assumptions should be favoured over conservative assumptions in this phase. It is important not to throw out the (rare) viable project through excessive caution at the scoping phase.

A study of this level is valid to determine whether a project is worth pursuing further but the uncertainty in the economic parameters suggests any reserve definition is generally not possible until later study phases. Any decision not to pursue the study in further detail should be taken in light of the order of accuracy of the study.

The work plan required to advance the project to the prefeasibility stage should focus on any additional drilling, sampling or metallurgical analysis required.

Prefeasibility study (Select phase)

Prefeasibility studies should be used to *select* the preferred operating options from the shortlisted options defined by the scoping study and to provide a case for whether or not to commit to the large expenditure and effort involved in a subsequent definitive feasibility study.

All shortlisted operating scenarios defined by the scoping study should be evaluated in the prefeasibility study with the objective of evaluating only one (or possibly at most two) scenario/s in the definitive feasibility study.

The geological definition work completed prior to commencement of the prefeasibility study should be sufficient to enable stage testwork for basic engineering such as process flow diagrams. The testwork and data generated during the prefeasibility study should be sufficient to be able to confidently generate realistic estimates of technical performance, capital and operating costs, manning requirements, price and marketability, environmental and social impact, project profitability and risks. The level of engineering work in a prefeasibility study should be no more than that is required to select an option/s.

By completion of the prefeasibility study there is often sufficient information to declare reserves, provided the project has positive economics.

The work plan required to advance to the feasibility phase should give particular consideration to geotechnical studies for mine, waste dumps and tailings facility design, as well as further metallurgical testing for refining estimates of product recoveries (bulk samples), and tailings disposal considerations.

Definitive feasibility study (Refine phase)

Definitive (full) feasibility studies should be used to *refine* the optimal operating scenario defined by the prefeasibility study. They are often used to assist with outside financing requirements. The definitive feasibility study provides the basis for the decision on whether in fact further study is required, whether the project is worth pursuing or whether to advance the project to design and construction.

All uncertain aspects relating to the project should be well defined and data collated, reviewed and audited prior to commencing the definitive feasibility study. The study in itself should be confirmatory in nature and should be carried out using samples representative of the final mine plan. There should be some consideration for doing pilot scale testwork and obtaining tendered mining rates if mining contractors are to be used.

Key components in the feasibility study are the mine design, production schedule, a detailed process flow sheet and piping and instrument diagrams, product recoveries for the suite of anticipated material types, detailed plant design, management plans, and a comprehensive economic model of the project.

The feasibility study usually does not go any further into detailed engineering design than necessary, so that typically 50 per cent of the engineering remains to be done after the feasibility study is complete. If it is a complex operation with multiple processes or new technologies, the level of engineering required for the feasibility might rise to 75 per cent or more (McCarthy, 2003).

At this point, in all cases there should be sufficient information to declare ore reserves, provided the project has positive economics.

At times, a definitive feasibility study is referred to as a bankable feasibility study. Whether there is any difference between a definitive and bankable feasibility study is debatable. The use of the term 'bankable' in replacement of definitive feasibility study is ambiguous and best not used as it implies that there is a underlying attractiveness to the investment which does not necessarily reflect the accuracy of the study.

Design and construction

The design and construction phase is about implementing the best option determined in the definitive feasibility study. This involves all the necessary detailed engineering design and procurement functions. This phase requires a manager with a focused mindset; intent on implementing the definitive feasibility plans (specifications) on schedule and within budget.

Construction management processes are typically common across all heavy construction industries. There are many sources of information available for describing good construction management process.

Operations

Once a project is constructed, it enters the operation phase. The purpose of this phase is to maintain highly efficient operational procedures making incremental adjustments to optimise the value of the project.

Phase accuracy ranges

As the project advances through the project, the accuracy of each phase improves. Typical accuracies of cost estimates for the various study levels are:

- scoping study: ±30 - 50 per cent,
- prefeasibility study: ±20 - 25 per cent, and
- definitive feasibility study: ±10 - 15 per cent.

However, without stating associated confidence levels, these accuracy intervals are somewhat meaningless and can be (and often are) misleading.

A true understanding of the likelihood that a project will exceed a certain financial hurdle should be performed by Monte Carlo analysis. Monte Carlo analysis provides an opportunity to understand the probability that a project will achieve certain critical hurdles given the interaction between all the individual input parameters that are not known with precision but a probability distribution can be prescribed. This style of analysis is not complex, makes intuitive sense when costs and revenue cannot be precisely defined, but is not commonly used in the mining industry.

Whilst uncertainty concerning construction costs is eliminated after completion of the design and construction phase, uncertainty regarding operating costs diminishes rapidly after the first year of operation. There is less reduction in uncertainty with regard to the ore reserves, mine life and grade until well into the operating life (Smith, 1997).

Contingencies

Contingency is a core component of a project estimate and is derived at the end of the estimate development process. Whilst often amounting to a significant cost, its purpose is often misunderstood and little effort put into determining an appropriate figure to use. Contingency must account for all the components of the project scope that are not yet identified, but will eventuate during project execution.

Contingency comprises:

- an amount to cover inaccuracies (in both quantity and price),
- allowance for the known shortfalls of the estimation process, and
- risk items resulting from a project risk assessment.

As the study process advances, more unknowns become known and quantified. It is therefore reasonable to expect a reduction in contingency as the project advances. The magnitude of the contingency is a more difficult figure to set. Typical figures applied to capital cost estimates are around 25 per cent, 15 per cent, and ten per cent, for the scoping, prefeasibility and definitive study levels respectively.

Some subjectivity surrounds the application of contingencies to operating costs depending on the source of the data. As it is often possible to estimate potential operating costs with a greater degree of accuracy, contingencies for operating cost estimates are often less that that for capital estimates, or not used at all. Industry standards or benchmarking may generate more confidence that all costs have been accounted for than first principles calculations alone.

The project diagram

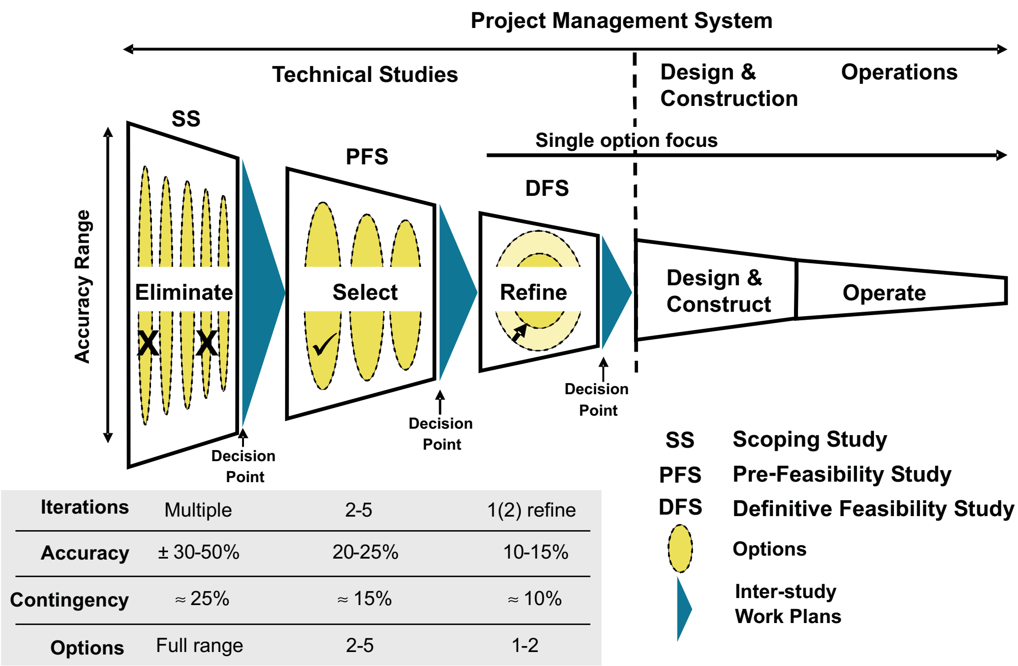
Figure 2 displays the various recommended phases of a mine development project.

EFFECTIVE PROJECT MANAGEMENT PROCEDURES

The solution

Whilst technical issues need to be recognised individually, the solution is in the governing process where these technical risks and issues are recognised and managed by proper processes of prior definition, communication and review.

Any set of project management procedures for the mining industry need to include:



Iterations	Multiple	2-5	1(2) refine
Accuracy	± 30-50%	20-25%	10-15%
Contingency	≈ 25%	≈ 15%	≈ 10%
Options	Full range	2-5	1-2

FIG 2 - Recommended phases of a mine development project.

- disciplined approach;
- clear definition of the problem and process;
- definition of agreed models, constraints and guiding principles (in advance);
- statement of objective for each phase and the required level of definition to satisfy the phase objective;
- project scheduling, tracking and communication; and
- independent audit/review.

The style of managing mining technical studies differs from that of construction projects. An integrated project management system for the mining industry needs to be able to take projects from scoping study through to operations and be adaptable to both technical study and design and construction environments.

By creating a consistent approach to project start-up and management, effective project management procedures will help to increase awareness of project scope, objectives, and resource allocation. Having a standard approach to project initiation and management will aid in the communication of project goals and deliverables, resulting in a reduction of unnecessary work and duplication.

Too many times the project management system and procedures are too complex or not well 'rolled out'. Features of a good integrated project management system generally consist of a set of simple to use yet effective procedures, templates and guidelines to assist mining organisations in successfully managing major projects. They are generally used for larger and more complex projects although components of the system can be used for minor projects. It is important to ensure those involved are trained and aware of the project procedures.

This section of the paper outlines a set of recommended project management procedures that the authors consider comprises the minimum necessary controls to ensure that mining projects are delivered successfully. Figure 3 presents the four key procedures required in every phase of a mine development project.

Project initiation

This is the first of the four key project management procedures.

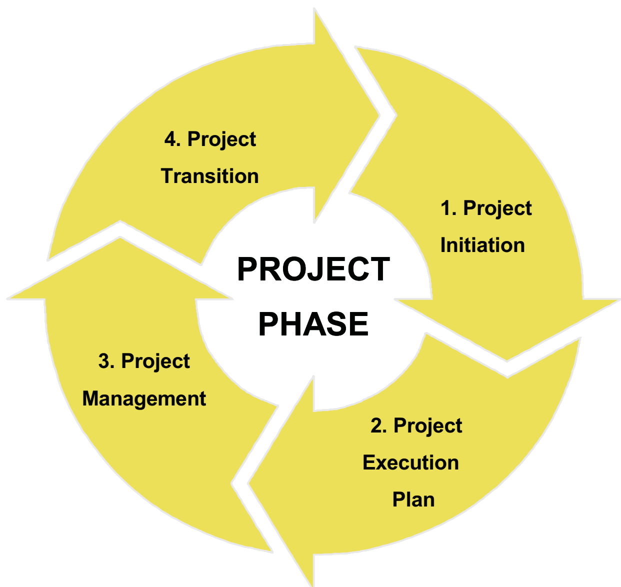


FIG 3 - The project cycle.

This procedure defines the process of project initiation and set up. It applies to the initiation of each project and individual project phases. As a minimum, the requirements of this procedure should be revisited each time a project advances from one phase to the next.

Project conception

The first step of initiating a project is to determine if the project idea should be progressed. A management forum is dedicated to exploring ideas. The forum provides opportunity to propose ideas for new projects and outline the key study components for new phases. In this context, it is essential that project ideas be clearly and succinctly communicated. The Project Idea Proposal is a simple document that summarises the essence of the idea, and the project rationale.

If a project is deemed to have potential, and is aligned with company strategy, the project sponsor will be appointed and will prepare or modify the current Project Charter (detailed below) and initiate the project.

Project preparation and management

Though the work tasks undertaken in the study, design and construction, and operation phases of the project differ, the method for defining, allocating, and tracking resources to those tasks remains the same through all phases of the project.

The three principal roles in initiating and managing a project are the project sponsor, project manager, and project customer. No project should be commenced unless these roles have been appointed and communicated.

The *project sponsor* is usually a senior executive/manager who approves and initiates the Project Charter. The project sponsor will appoint the project manager and will monitor progress on a regular basis. The sponsor will also help the project manager to remove any unexpected barriers.

The *project manager* is directly responsible for organising and managing a project phase. The project manager is responsible for taking the Project Charter, developing a detailed Project Execution Plan for the phase, and overseeing the project on a day-to-day basis.

The *project customer* is generally the person who will receive the deliverables of a project. In some cases, this person will be the project manager of the subsequent project phase, or the final operations manager.

Figure 4 describes the relationship between the key project roles.

For larger projects, a role of project director can be appointed. A project director can be used to ensure that the project procedures are followed and the requisite reviews are performed satisfactorily, etc.

Project Charter

When a major project is conceived and deemed appropriate, a Project Charter is drafted. The Project Charter is a clear and concise document (two to three pages) which articulates the overarching rationale behind the project, the principal objectives, and the scope of the project. It is the project sponsor's responsibility to oversee the drafting and approval of the Project Charter and ensure that the Project Charter is signed by the relevant project roles.

The purpose of the Project Charter is to clearly define and communicate the following:

- high level rationale for initiating the project;
- objectives of the entire project;
- objectives of the current phase (ie scoping, prefeasibility, definitive feasibility, design and construction and operation);
- primary deliverables of the project phase;
- cost and high level schedule of the project; and
- scope and battery limits of the project.

It is important that if external consultants are to be used, they should be involved in setting the scope, budget and battery limits of the Project Charter.

Although the project sponsor has the responsibility of preparing the Project Charter, the project manager and project customer will assist. All three parties must agree and sign off the document before the project begins. It is important to have the project customer's input on the Project Charter and initiation process to ensure that the transition between project phases is smooth and no essential information is lost.

If a project meets the criteria for requiring a Project Charter, an Application for Expenditure for the project will not be approved until both the project sponsor and the project customer have signed the Project Charter.

Further detail pertaining to scope, budget, and specific deliverables will be developed in the Project Execution Plan described below.

Figure 5 describes the role of the Project Charter from phase initiation to transition.

If at any point during the project there is a major change in scope or objectives, the Project Charter must be revised and agreed by the project sponsor, manager, and customer. Any change of the Project Charter requires sign off from all three parties, showing full agreement and understanding of the new terms.

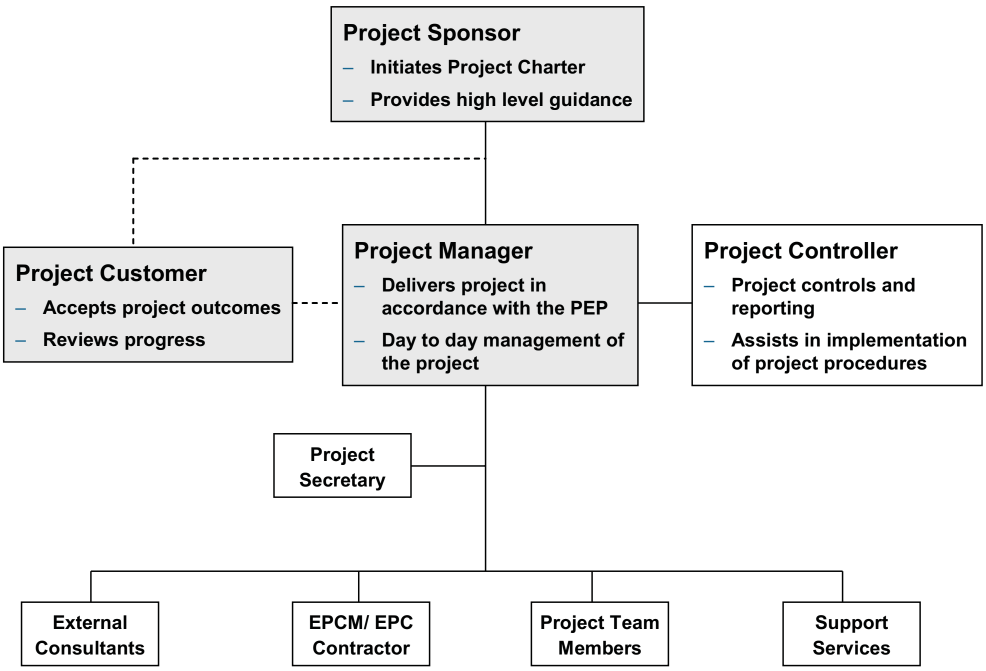


FIG 4 - Project role organisation chart.

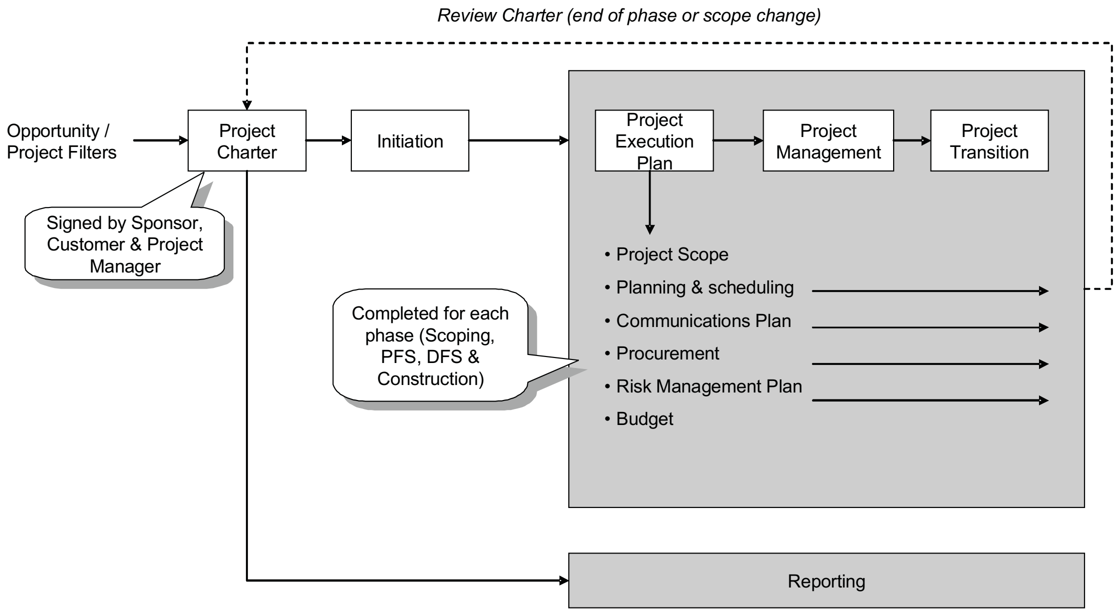


FIG 5 - The role of the Project Charter.

When the Charter is changed, it is the responsibility of the project manager to revise the Project Execution Plan to ensure that all resource allocations, schedules, and reporting mechanisms are still appropriate within the new scope.

Application for expenditure approval

Once the Project Charter has been approved by at least the project sponsor and customer, it can be submitted along with an Application for Expenditure for approval at the appropriate level within the organisation, depending on the magnitude of risk.

Once the Application for Expenditure is approved, the project sponsor will be notified and the project will be registered and assigned a cost code. At this point, work on the project can begin.

Project manager's briefing

A formal briefing meeting should be held (at the time of the project manager's appointment) involving the project sponsor, the project customer, and the project manager. The purpose of the meeting is to review the Project Charter and the approved Application for Expenditure, to provide direction on the project objectives, agree on the project outcomes, and have the project manager sign off on the Project Charter.

The meeting is the project manager's opportunity to raise any issues that surface in his review of the project framing and approval documentation. Obvious issues with scope, budget, timing, quality and perceived risks should be addressed (such as the state of geological resource and metallurgical modelling). There should be a clear definition of the battery limits of the project manager's scope and budget (including definition of the limits of project contingency and the agreement on rules for managing project scheduling and realistic production rate targets).

Projects are discrete entities and contractors as third parties may be used as project manager. The project sponsor shall ensure that the project manager is aware of and understands:

- company policies that have an influence on the required conduct of projects,
- project management system procedures,
- documentation/retention of intellectual property, and
- other relevant business processes.

Project procedures

Major projects will generally require project specific procedures. EPCM contractors shall be required to implement project specific procedures for projects (eg safety, ground support, equipment operation, drilling and blasting procedures). The project manager, in coordination with the relevant company officers is responsible for ensuring that all contractors/consultants' procedures are in line with company requirements.

Project procedures will generally be the combination of standard company procedures and once-off procedures dealing with project-specific issues and requirements (possibly identified during the project risk assessment).

Project kick-off meeting

Prior to starting the project, the project manager shall hold a project kick-off meeting with all the relevant project staff to explain and discuss the elements of the Project Execution Plan (discussed below). It may be necessary to hold preliminary meetings with key team members while the Project Execution Plan is being developed.

Prior to the external services provider (EPCM or technical/engineering consultant) commencing work, the project manager shall hold a project kick-off meeting with the external services provider. In some instances, external service providers may attend all or part of the kick off meeting.

Correspondence, filing and document control

Upon project initiation the project manager, or his delegate, should establish the following:

- the project filing system,
- project correspondence protocols, and
- the system of project document control and coding.

Project Execution Plan

This is the second of the four key project management procedures.

The Project Execution Plan clearly defines the scope and boundaries of each work package (what is included, what is excluded, and what are the base assumptions). The project manager outlines the deliverables of the phase and breaks them down into all the work tasks (or packages) that need to be completed for the deliverables to be achieved. A resource chart is created listing all the project team members (including all external consultants and contractors to be engaged) and tasks are assigned to the appropriate team member.

The interface between the study phase and design and construction phase is an important delineation in a project and as such, effective integrated project management systems ensure a smooth transition by involving the project managers of both phases in preparing the Project Execution Plan for the study.

Preparation of the Project Execution Plan is generally the project manager's first task on the project phase. At the start of the first phase, and each following phase through to project completion, the Project Initiation procedure is used to develop a Project Execution Plan for the phase. It is the primary control document for the project.

There are eight major components to a complete Project Execution Plan:

- project work breakdown structure;
- defining the project team, their roles and responsibilities;
- determining the detailed project schedule;
- establishing milestones;
- project budget;
- formalising the communication plan (meetings, reports and KPIs);
- risk assessment; and
- major procurement and contracts plan.

A further use for the Project Execution Plan is to define the reporting strategy, progress measurement indicators, and communication plan for the phase. Before beginning the project, the project manager defines in the Project Execution Plan the progress indicators to be tracked through the phase and the reporting and communication mechanisms by which the tracking will be executed. This process involves defining regular meetings and reports, and the interaction of the project manager and team with all the support departments.

Once the Project Execution Plan is complete and approved by the project manager, sponsor, and customer, the actual work of the phase commences. The project manager is responsible for providing leadership and direction to the project team through the mechanisms and procedures outlined in the Project Execution Plan.

When all the deliverables of the Project Execution Plan have been achieved and the project phase is complete, the project manager is responsible for overseeing the project transition through to the customer, or next phase.

Upon completion of the phase, the Project Charter is updated if necessary and the preparation of the Project Execution Plan for the next phase is undertaken.

Project management

This is the third of the four key project management procedures.

This procedure defines the roles, responsibilities and procedures to be followed for the management of a project once it has commenced. It is a guiding document to assist project managers with the day-to-day management of their project. The emphasis of this procedure is on using the Project Execution Plan as a tool to achieve all the deliverables of the project in a manner that allows for easy progress measurement and communication. The procedure also provides guidance on management techniques for different phases of a project, from scoping studies through to design and construction, and operation.

Once the initial planning of the project is complete, four key elements contribute to the project's successful execution:

- selecting and building an effective project team,
- accurate and timely progress and cost tracking,
- effective communication and reporting, and
- review/audit.

Building an effective team

The most important aspect to building an effective team is to provide motivation and support through good leadership. Key aspects include:

- establish 'ground rules' at the beginning of the project (and regularly review),
- ensure that team members' personal objectives align with project goals,
- provide frequent and constructive feedback,
- resolve conflicts and issues early, and
- leverage team members' skills and abilities.

Another important part of managing an effective team is to create a project focus in contrast to an operational orientation. The distinct difference is that a project has a fixed start and finish with clear objectives and deliverables. Some suggestions to help create this 'project focus', particularly for larger projects include:

- have a dedicated project office;
- set a clear team calendar (meetings, reviews, etc);
- track performance and progress regularly and make available to team members;
- have the project objectives and progress clearly visible in the project office; and
- appoint a dedicated project controller to measure progress, prepare reports and drive meetings and schedules.

In the Project Execution Plan, the project manager defines a communication plan that describes the meetings and reports that will be used during the project. It is the project manager's responsibility to facilitate weekly team progress meetings. The objectives of the weekly meeting are to:

- track project progress,
- ensure individual team members can see the overall picture of the project,
- provide a forum for team members to share information pertaining to the project,
- identify problem areas,
- set the direction for the coming week and provide an 'action list', and
- build team commitment and relations.

It is the project manager's responsibility to ensure that the project sponsor and key stakeholders are updated regularly on project progress and key issues arisen. This weekly update allows the sponsor to provide high-level direction to the project and to stay up to date on progress. As the sponsor may have multiple interrelated projects underway, the updates ensure that there is adequate communication/integration across projects.

It is the project manager's responsibility to facilitate a contract review meeting for all major contracts in the project. The purpose of the meeting is to keep the company officials up to date on any contractual issues. The project manager, relevant company official, and a representative of any major contractor/consultant should be present at the meeting.

Progress tracking

The purpose of project tracking and reporting tools is to gather accurate and timely information about the progress of a project. This will enable the project manager to understand the performance of the project, determine leadership needs, and manage change to get the project back on track (if needed). It is also important to regularly and clearly communicate pertinent key performance indicators (KPIs) to project sponsors and executives so that all stakeholders understand the status of the project.

The key guidelines to all tracking and reporting programs are:

- only track what is useful – develop simple, project specific KPIs relating to progress against scope, budget and schedule;
- use simple graphical tools/charts where possible;
- develop targets against which progress can be measured;
- identify variance between target and actual progress;
- clearly communicate critical variances through KPIs and charts;
- determine the reason for variance; and
- propose changes to remedy variance.

Unlike design and construction and operations projects, studies do not have physical results by which to measure progress. Much of the activity is about building knowledge to enable a decision or recommendation. However, study projects often involve large teams, multiple interrelated tasks and tight schedules. It is important to track the progress of a study accurately to give management a meaningful insight into the state of the project. It is recommended to use the detailed project schedule and milestones established in the Project Execution Plan as a target.

The design and construction phase of a project is where the majority of the total project costs occur. It also covers many concurrent activities and therefore requires carefully targeted KPIs. As each design and construction project is different, indicators need to be developed and tracked on a project-by-project basis. It is important to have a few overarching KPIs such as 'per cent complete', the monthly budget, and project milestones through which overall project progress can be communicated.

Reports

Concise yet complete reports are the backbone of effective project communication. They allow project sponsors and key stakeholders a snapshot into what is happening with a project. Weekly reports should be used as a tool to keep stakeholders aware of any project issues, and to instil confidence that the project manager is successfully handling all the issues and priorities associated with a project.

More formal, comprehensive updates on the project are held less often but typically monthly. They include the budget numbers, an updated Gantt chart and a description of the period's progress.

To avoid redundant work and ensure standard references for communications, it is important that all reports reflect the KPIs established in the Project Execution Plan and are tracked during the life of the project.

Peer review/audit

At key technical milestones within phases and always prior to transitioning the project to the next phase, a peer review team should be assembled with the objective of critically analysing all the identified risk factors and associated assumptions made to that point in the phase study. This provides the project team confidence that the project either can be advanced to the next aspect of the study or phase, or highlights the further work that is required.

The object of peer review or audit should be to *independently* examine the relevant category of project fundamentals, which can be classified as follows:

- technical,
- environment-social,
- legal, and
- economic.

The members of this peer review team/s should consist of senior company officials, the project owner, stakeholders, and (external) industry experts, depending on whether the company has the level of experience required internally. The number of teams, extent, and content of the peer review/audit should depend on the level of the study and perceived order of magnitude of risk.

To avoid confusion, it is important that peer review team members restrict the scope of the exercise to reviewing risk factors and assumptions only.

Project transition

This is the fourth of four key project management procedures.

This procedure defines the transition process that occurs between phases of a project and at the completion of a project. This process is applicable to all projects. It should be used to maintain continuity between project phases and to ensure that vital information and knowledge is communicated from one project team to the next. It needs to be understood that often there are time gaps between when one project phase finishes and another starts.

Completing a study project

With respect to a study project, effectively communicating the results of the study are as important as the work itself. The objective of a study is to provide decision makers (management team/executives) with sufficient information to make a decision to move the project to the next phase, put it on hold, revisit specific aspects, or to terminate the project.

The research the study is based on, as well as the study documents themselves, need to be properly documented and filed so they can be picked up in the future by teams working on further phases of the project.

Study results should be formally communicated to:

- project sponsor, customer and stakeholders;
- project team; and
- wider organisation.

Project sponsor, customer and stakeholders

The formal study report should be presented to the sponsor, customer and stakeholders in the form of a written final report and summary presentation. The presentation should include the key findings of the study and any related recommendations. Ideally, the project team should be present at the presentation to help the project manager cover any technical questions.

The project team

While team members know the results of their part of a project, it is important to ensure that the 'big picture' results of the study are clearly communicated. In particular, team members should be made aware of outcomes from the presentation to the project sponsors and stakeholders, and the associated impact on the continuation of the project into further phases.

The wider organisation

It is important that some form of report or update is available to the wider organisation beyond the project team and stakeholders. This keeps everyone in the organisation up to date on the big picture issues and minimises speculation. A brief company memorandum or internet announcement is an effective tool for communicating the key findings of the study.

Completing a construction project

Completing a construction project requires properly closing out all contracts and handing over the project to the operations manager. Specific commissioning and handover procedures involving the customer/customer's team should be developed during the course of the design and construction phase.

Project and team review

After the project is complete and all results have been presented, a final team meeting should be convened. The goal of the review meeting is to elicit frank feedback from team members as to how the project was run, what worked, what did not, and how the process could be improved for the next project. These insights should be captured in a report and used as knowledge for future projects. The following points may be considered during the review:

- review charter and initial objectives and compare with actual results delivered;
- discuss the effectiveness of milestones and KPIs selected for the project;
- team and individual performance reviews; and
- capture key learnings (intellectual property developed, what worked well, areas for improvement, feedback into the integrated project management system).

Project close out

Closing out the Application for Expenditure

At the end of the project, the project manager should ensure that all costs are accounted for and the final project cost is captured.

Contract close out for construction projects

When closing out a project, or project phase involving contractors, particular attention needs to be paid to the contract documentation to ensure satisfaction of all contract provisions.

Filing project documents

Upon project completion, it is important to ensure that all project related documents are filed in an organised and accessible manner (particularly for studies with a delay before the design and construction phase).

All project management documents including the signed Project Charter, and final Project Execution Plans should be filed within the centralised filing system.

All other project documents, including correspondence records should be stored electronically in a folder dedicated to the project.

Initiation of next phase

An important aspect of a smooth transition between project phases is ensuring that the key players for the next phase are involved in the process at an appropriate time. Key activities to assist this process include:

- review Project Charter for the upcoming phase;
- ensure key players for next phase are involved at the appropriate time; and
- develop specific procedures (eg commissioning, training, contract management).

Project reconciliation

At least once during the life of the operation, it is beneficial to review performance against that proposed by the feasibility study. This provides many insights into the strengths and weaknesses of the study phases. Learnings from this should then be built into future studies.

CLOSING REMARKS

This paper has highlighted the issues that the mining industry is facing with an increasingly limited pool of skilled technical resources to complete mining projects in a cost inflationary environment. To minimise project delays and cost overruns, mining companies need to become more efficient in managing their development projects.

This paper provides recommendations as to what should be the standardised components and objectives of each phase of a typical mine development project. It highlights issues that commonly prevail in typical project management procedures and attempts to provide a solution to those issues by extracting components of project management procedures available, and adding components and functionality to generate an effective integrated project management system. This system can be used to manage the entire mining project from scoping studies through to operations.

Due to the inherent uncertainties that are characteristic of the mining environment, managing technical studies as part of mining projects will never be easy, nor will they always be successful. However with an effective fully integrated project management system governing the mine development project such as that outlined, the likelihood of success will be greatly improved.

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